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The determinants of aggregate variables in different exchange rate systems

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THE DETERMINANTS OF AGGREGATE VARIABLES
IN DIFFERENT EXCHANGE RATE SYSTEMS

V. Alexander and H.-E. Loef

Serie A - Nr. 132

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1. Introduction

This paper analyses the effects of monetary policy under different exchange rate systems on the following macro-economic variables: real output, employment, inflation, interest rates, and exchange rates. Theoretical models are constructed, relating real economic variables to unanticipated and nominal variables to anticipated changes in monetary growth

Three exchange rate systems are considered explicitly: flexible and fixed exchange rate systems and dirty floating. In the flexible exchange rate system only unanticipated money growth and deviations from the relative purchasing power parity have effects on the real economy. In the other two exchange rate systems an additional channel of real disturbances emerges through unanticipated exchange rate movements.

An empirical example for West-Germany shows that both real GNP and employment are well explained by the underlying theoretical models. In particular the difference between actual and expected exchange rate movements has a great influence on real aggregate variables. No support is given for purchasing power parity effects.

This paper is an extended version of our paper "Unanticipated Monetary Variables and Real Effects in an Open Economy" which was submitted to and discussed at the Konstanz Seminar on Monetary Theory and Monetary Policy, June 1979.

2. The Problem

Within the current debate about the relevant explanation of fluctuations in real output and employment more and more attention is paid to the hypothesis that only unanticipated movements in monetary variables have real effects (see Barro (1977), Meltzer (1977), Neumann (1978). This hypothesis is the result of several theoretical developments in the last 10 to 15 years.

At first the discussion about the meaning of the "rational expectations hypothesis" in a macroeconomic context has to be mentioned (e.g., Gordon (1976), Muth (1961), Shiller (1979)). As Lucas (1972), Barro (1976) and Sargent - Wallace (1976) have shown in their rational expectations analysis of the Phillips - relation, cyclic movements of the employment level as a consequence of monetary policy can only occur if the money supply growth rate and therefore the inflation rate is incorrectly anticipated. In a situation of overall perfect anticipation the economy remains at the "natural rate of unemployment. Monetary policy will then only influence the price level and determine the speed of inflation.¹⁾

Beside the rational expectations theory, which concentrates on the real effects of unanticipated money growth in the aggregate labour market, two other theoretical developments had a significant influence on the evaluation of the initial hypothesis: the increasing attention that is paid to the microeconomic foundation

of aggregate relations (see Weintraub (1977)) and the greater importance of the supply side in macroeconomic analysis. This can be demonstrated by the following typical example (see Alchian (1976)): in fixing his prices and quantities an entrepreneur, who plans his production for the coming period, needs perfect informations about the present and future position of the nominal demand curve he is confronted with. Only if he exactly forecasts the demand for his goods he will be able to sell his whole production at the fixed price. In the case of an incorrect forecast, he is faced with "surprises" in the form of unplanned inventories or excess demand for his goods. These real effects then lead to adjustment processes, which take the form of quantity - and price - adjustments corresponding to the relative transaction and information costs of these two possibilities.

These considerations can be translated to the macroeconomic level. To forecast the nominal aggregate demand all suppliers would need informations about future price movements. Fluctuations in the aggregate real supply of goods and in the employment level result from incorrect anticipation of the inflationary development.

These briefly - presented, theoretical considerations are the basis for the general view of the aggregate transmission mechanism: expected changes in monetary variables mainly influence the price level, whereas unanticipated changes especially affect real output and employment.

In the existing literature this general view of the transmission process is only scarcely treated in a systematical way. Barro (1977) concludes from an empiric study using US-data, that the unemployment rate is dominantly determined by unexpected changes in the money supply. For West-Germany Neumann (1978) formulated an impulse - theoretic model that is consistent with modern price theory. He shows that rational expectations of future inflation rates are the most important channel through which the effects of policy impulses are transmitted to monetary and real aggregate variables. Inflation is best explained by expected policy changes; unexpected impulse changes are the main determinant of fluctuations in real output (see Neumann (1978), p. 265).²⁾

The main purpose of this paper is a theoretical and empirical analysis of the above view of the transmission process in an open economy. In contrast to Barro (1977) we have to consider unanticipated changes in exchange rates as an argument for real fluctuations. If for example a devaluation of home currency is expected, real effects enter the economy via different channels. Export can increase their profits by delaing their export sales so that the actual physical amount of exports decreases. On international capital markets the expectation of a devaluation of home currency leads to a diminished demand for home money: transactors expect an increase in the value of foreign bonds and money compared with home financial assets. As a consequence a net capital export occurs with the well known corresponding effects on home capital and goods markets.

To include the real effects of unanticipated exchange rate movements, we construct a simple model for an open economy in which expectations about the future behavior of the money stock and the exchange rate play a crucial role. Within the specification of the international relationships our economy is involved in, we incorporate some new developments in balance of payments - and exchange rate - theory (e.g. Dornbusch (1976), Mussa (1976)). It is assumed that the balance of payments can be treated as a mainly monetary phenomenon and can adequately be explained by a stock - adjustment process of international portfolios (see Kouri and Porter (1974), Swoboda (1976), Willet and Forte (1969)). Within this theoretical context exchange rates are defined as relative prices of different national currencies (not of national outputs). They are determined by the equilibrium conditions in markets for stocks of assets, not for flow of funds (see Mussa (1976, p. 233)).

From the solution of the model we obtain testable reduced - form equations, in which the effects of unanticipated money and exchange rate movements on real output and employment are exposed.³⁾ The also deduced reduced forms for the inflation rate and the interest rate changes are not tested in this paper. We consider the possibility of different exchange rate systems by modifying our basis - model for flexible and fixed rates as well as for dirty floating.

The reduced form equations for real GNP and employment are tested empirically with German data. Our main result is that unanticipated exchange rate movements had larger real effects than unexpected money growth.

3. The Complete Model

3.1. The Structural Equations

The following model refers to four aggregate markets: the labour, goods, money and currency markets. Equation (1) connects the labour market and the supply side of the

$$(1) \quad y^s = y^p + \frac{1}{a} (\hat{P} - \hat{P}^e)$$

aggregate goods market (y^s = real supply of goods and y^p = potential output). It is based on the well known price - expectations - augmented Phillips curve

$$u = u^* - a_1 (\hat{P} - \hat{P}^e)$$

in which the unemployment rate u depends on the natural rate of unemployment u^* (see Friedman (1977), Prescott (1975)) and the difference between the actual (\hat{P}) and the expected (\hat{P}^e) inflation rate. We further assume a simple production-function

$$y^s = y^s \left[(1-u)N, C \right]$$

where $(1-u)N$ stands for the actual level of employment (i.e., the input of the labour factor) and C for the

constant input of other factors of production. If we define the potential output y^p (see Rasche - Tatom (1977)) so that it is only reached at the level of unemployment u^* , we can write (see Dornbusch and Fischer (1978, p.405)):

$$u - u^* = -a_2(y^s - y^p)$$

Under the assumption that $a = a_2/a_1$ we obtain the specification of aggregate goods supply in equation (1).

It should be stressed here that y^s contains all expectations of inflation in the labour market. y^s can only be different from the potential output y^p if the inflation rate is incorrectly anticipated in the labour market: $\hat{P} - \hat{P}^e \neq 0$.

Equation (2) specifies the aggregate real demand for goods in an open economy:

$$(2) \quad y^d = y^d(y, i, P/P_A x, x/x^e, y_A)$$

$$y_1^d, y_4^d, y_5^d > 0; \quad y_2^d, y_3^d < 0$$

In (2) the real demand for goods is explained by the domestic and foreign real incomes, y and y_A , the interest rate i , the relation between the domestic (P) and foreign (P_A) price level, where P_A is valued in home currency

(i.e. $P_A x$ with x standing for the exchange rate), and the ratio of the actual to the expected exchange rate x/x^e .

Some remarks are necessary regarding the partial derivative y_4^d . The inclusion of x/x^e as an argument to explain y^d refers to the timing in the transaction plans of exporters and importers. If a devaluation of home currency is expected ($\hat{x}^e > 0$) but not realized at present there will be an increase in the revenue of all export transactions valued in foreign currency, which bear the date of the expected devaluation. The exporter therefore reduces the actual volume of exports because he is able to increase his profits from export contracts bearing a later date. The above considerations also apply to a foreign importer who would also be interested in a later dating of all contracts valued in home currency. Both considerations lead to the positive sign of y_4^d .

The goods market is completed by the equilibrium condition

$$(3) \quad y^s = y^d = y$$

To integrate the monetary sector we first define the real demand for money (M^d/P): 4)

$$(4) \quad M^d/P = L(y, i, x/x^e, y_A)$$

$$L_1, L_3, L_4 > 0; \quad L_2 < 0$$

Equation (4) expresses the fact, that in an open economy the real demand for money is not only explained by the standard arguments y and i , but also by the ratio x/x^e and the foreign real income y_A . If y_A increases, foreign transactors rearrange their portfolios. One part of the additional y_A is allocated to domestic goods and financial assets, which leads to an increase of M^d/P .

M^d/P is also positively influenced by the ratio x/x^e : the expectation of a devaluation in home currency ($\hat{x}^e > 0$) diminishes the demand for domestic money and leads to a supply pressure in the market for domestic bonds. This substitution of foreign financial assets for home bonds seems to be profitable, because of the expected increase in the value of foreign bonds after the devaluation of the home currency.

Equations (5) and (6) determine the nominal money supply M^s , which consists of a domestic (DA) and a foreign (FA) component, and the equilibrium in the money market:

$$(5) \quad M^s = M^s(DA, FA)$$

$$M_1^s, M_2^s > 0$$

$$(6) \quad M^s = M^d = M$$

In our model DA is treated as exogenous. We assume that DA is effectively controlled by the domestic monetary authorities. DA represents in the model the vector of

monetary policy instruments. The FA component, however, depends on the international economic activities of the analysed country and is therefore determined by the behavior of the balance of payments. This relation is defined in equation (7):

$$(7) \quad \Delta FA = Z(P/P_A x, x/x^e, i/i_A, y/y_A)$$

$$Z_2, Z_3 > 0; \quad Z_1, Z_4 < 0$$

The equation is derived from the nominal balance of payments identity.⁵⁾ A change in the net foreign position of monetary authorities ΔFA is equal to the consolidated balance in the current and capital account. ΔFA first depends on the foreign and domestic price level (a point that is particularly stressed by the theory of purchasing power - parity, where ΔFA is assumed to be dominantly influenced by real international transactions).

The remaining arguments in equation (7) clearly show, that the balance of payments has to be treated as a main monetary phenomenon and that international capital flows are determined by a stock - adjustment process. As in other asset markets the conditions in the market for currency are dominantly influenced by expectations of future asset prices. It follows that under flexible exchange rates the actual rate x depends on the expected rate x^e . In a system of fixed rates a constellation $x/x^e \neq 1$ leads to balance of payments surpluses or

deficits. If for example a devaluation of home currency is expected ($\hat{x}^e > 0$), all portfolios are rearranged in favor of assets, that are denominated in foreign currency. The demand for foreign money increases and as a consequence ΔFA is reduced.

A similar stock - adjustment effect occurs after a change in the ratio of domestic to foreign interest rates i/i_A , because the relative yields of domestic and foreign financial assets have changed. An increase in i leads to a portfolio adjustment in favor of home bonds. This causes a higher demand for domestic money. In the systems of flexible or fixed exchange rates we get as a result an increasing x and a higher ΔFA respectively.

The two analysed effects are short - run phenomena and disappear when all domestic and foreign portfolios are adjusted to the changed conditions. A longer - run influence on the balance of payments arises from changes in the ratio y/y_A . This so-called "flow - effect" captures the demand for home currency stemming from growing portfolios (see Hodjera (1973, p.704)). An increase in y causes net capital exports and higher demand for imports, because part of the additional home income is allocated to foreign goods and financial assets. A net demand for foreign currency emerges leading to a decrease in ΔFA , so that $Z_4 < 0$.

By adding the two definitions:

$$(8) \quad P_t = P_0 e^{\hat{P}_t} \quad \text{and}$$

$$(9) \quad FA_{t-1} = \sum_{i=1}^{\infty} \Delta FA_{t-i}$$

we obtain a system with the following set of variables:

endogenous
variables: $y^d, y^s, P, \hat{P}, i, x, M^s, M^d, FA, \Delta FA$

exogenous
variables: $y^p, P_0, P_A, y_A, DA, \hat{P}^e, x^e$.

For a complete determination of the model we need to specify the underlying exchange rate system, because within the equations (1) to (9) both the exchange rate x and the balance of payments disequilibrium ΔFA are treated as endogenous.

Equation (10) is needed to obtain a flexible exchange rate system, where balance of payments disequilibria are impossible and x becomes an endogenous variable.

$$(10) \quad \Delta FA = 0$$

Alternatively a system of fixed rates is obtained by adding the equation (11):

$$(11) \quad x = \bar{x}$$

The exchange rate x is fixed by monetary authorities so that we are confronted with deficits or surpluses in the balance of payments ($\Delta FA = \text{endogenous}$).

As a third system we introduce dirty floating, where monetary authorities determine to which extent external disequilibria lead to changes in x and FA respectively.⁶⁾ This is included in our model in the following way: for equation (5) we define the money supply as an exogenous variable, because monetary authorities control DA and FA :

$$(12) \quad M^s = \bar{M}^s$$

A dirty floating - policy further implies that equation (7) disappears. As a consequence equation (9) is also unnecessary. The last modification consists of the inclusion of (11), because , as in the case of the fixed rate system, x becomes exogenous. Our dirty floating - system is then defined by the equations (1) to (4), (6), (8), (11) and (12) with the endogenous variables y^d , y^s , P , \hat{P} , i , x , M^s and M^d .

3.2. Flexible Exchange Rates System

In a system of flexible exchange rates the balance of payments is in equilibrium for every period ($\Delta FA = 0$) because external disequilibria always lead to fluctuations in the actual exchange rate in the proper way. This constellation is captured by equations (1) to (10). Ignoring the definitional equations (8) and (9) and using the market equilibrium conditions (3) and (6) the model for the case of flexible exchange rates can be written in matrix form. To do this equations (1) to (10) are totally differentiated, assuming that the relationship between the variables is linear in their logarithm (except for y where we use the absolute difference instead of the growth rate). As usual \hat{x} means the growth rate of x .

Table 1

System I: Flexible Exchange Rates

$$\begin{bmatrix} 1 & -1/a & 0 & 0 \\ 1 & y_3/g & y_2/g & -\frac{y_3+y_4}{g} \\ -(L_1-L_4) & -1 & L_2 & -L_3 \\ -Z_4 & -Z_1 & Z_3 & Z_1+Z_2 \end{bmatrix} \times \begin{bmatrix} y \\ \hat{p} \\ \hat{z} \\ \hat{x} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & -1/a & 0 \\ 1 & 0 & y_5/g & 0 & y_3/g & 0 & -y_4/g \\ -(L_1-L_4) & -1 & L_4 & 0 & 0 & 0 & -L_3 \\ -Z_4 & 0 & -Z_4 & Z_3 & -Z_1 & 0 & Z_2 \end{bmatrix} \times \begin{bmatrix} y^p \\ \hat{M} \\ \Delta y_A \\ \hat{z}_A \\ \hat{p}_A \\ \hat{p}^e \\ \hat{x}^e \end{bmatrix}$$

$$\begin{array}{ccc} A_I & \times & Y_I \\ 4 \times 4 & & 4 \times 1 \end{array} = \begin{array}{ccc} B_I & \times & Z_I \\ 4 \times 7 & & 7 \times 1 \end{array}$$

where $0 < g = 1 - y_1 + y_5 < 1$ and $L_1 - L_4 > 0$.

It is also assumed that $y_{t-1} = y^p$. Without this assumption the whole system would result in a system of difference equations which would increase the grade of mathematical complexity but not necessarily and significantly the economic content.

The main determinant of the coefficient matrix of system I is

$$\begin{aligned} \det A_I = \frac{1}{ag} \{ & y_2 [aZ_2 + aZ_1(1 + L_3) + L_3Z_4 + (Z_1 + Z_2)(L_1 - L_4)] \\ & + y_3 [aZ_2L_2 + aZ_3(1 + L_3) + Z_3(L_1 - L_4) - L_2Z_4] \\ & + y_4 [aZ_3 + Z_3(L_1 - L_4) - L_2(aZ_1 + Z_4)] \\ & + gL_2(Z_1 + Z_2) + gZ_3L_3 \} \end{aligned}$$

which tends to be positive, provided the elasticity of the balance of payments with respect to the purchasing power parity effect and the relative development of income at home and abroad are sufficiently small. The latter elasticity measures a long-run influence on the balance of payments resulting from growing portfolios.

In the short run, in which we are interested in, this elasticity could be assumed to be rather small. The effect of a divergence between movements in exchange rates and the inflation differential can also be considered to have a more long-run impact than a short-run. From theoretical considerations therefore it can be assumed that the main determinant of the coefficient matrix A_I ($\det A_I$) is positive:

$\det A_I > 0$ provided that Z_1 and Z_4 are sufficiently small

Using Cramer's rule we obtain the following structure of dependence between the exogenous and the endogenous variables for the flexible exchange rate system in Table 2 below.

Each cell shows the influence of the exogenous variable (shown in the first column) on the endogenous variables (shown in the first row) for the flexible exchange rate system. To get the total reduced form of the system the expression in each cell must be divided by the main determinant $\det A_I$ premultiplied by ag . As can be seen not every relationship has an unambiguous sign. Table 3 shows the qualitative relationships for the general case. In most cases order conditions are necessary. Instead of listing all relevant necessary and sufficient order conditions we assume again that only two elasticities are small enough: that is Z_1 and Z_4 , which have been mentioned previously. If these two elasticities are sufficiently small again, we obtain in Table 4 a representation of the qualitative relationships between the exogenous and endogenous variables for the case of the flexible exchange rate system.

| ENDOGEN. | M | | Δ M | Δ A | DEVIDED BY |
|----------|--|---|--|-----------------------|------------|
| y | $(y_3 + y_4) z_3 + (z_1 + z_2) y_2$ | $(z_1 + z_2)(y_5 L_2 - L_4 y_2) - (y_3 + y_4)(L_2 z_4 + L_4 z_3) + L_3(y_2 z_4 + y_5 z_3)$ | $z_3 [(y_3 + y_4) L_2 - y_2 L_3]$ | ag det A _I | |
| Ĥ | $(y_3 + y_4) z_3 + (z_1 + z_2) y_2$ | $(z_1 + z_2)(y_5 L_2 - L_4 y_2) - (y_3 + y_4)(L_2 z_4 + L_4 z_3) + L_3(y_2 z_4 + y_5 z_3)$ | $z_3 [(y_3 + y_4) L_2 - y_2 L_3]$ | g det A _I | |
| î | $z_4(y_3 + y_4) - z_1(g - ay_4) - z_2(g + ay_3)$ | $[z_1 + z_2][y_3 L_4 a + y_5 a + L_4 g + (L_1 - L_4) y_5] - (y_3 + y_4)(z_4 a + z_1 L_4 a + L_1 z_4) + y_5 L_3(z_1 + z_4) - z_4 L_3(y_3 a + g)$ | $z_3 [L_3(g + y_3 a) + (y_3 + y_4)(a + L_1 - L_4)]$ | ag det A _I | |
| Ĥ | $z_3(y_3 a + g) + y_2(z_4 + z_1 a)$ | $-[z_1 a(y_2 L_4 - y_5 L_2) + z_3[y_5 a(1 + (L_1 - L_4)g) + L_4(y_3 a + g)] + z_4[L_2(y_3 a + g(1 - y_5) + y_2(a + L_1 g))]]$ | $z_3 [L_1(a y_3 + g) + y_2(a + L_1 - L_4)]$ | ag det A _I | |
| ENDOGEN. | Ĥ _A | Ĥ _e | Ĥ _e | TO BE DEVIDED BY | |
| y | $y_3(L_2 z_2 + L_3 z_3) + z_1(y_2 L_3 - y_4 L_2)$ | $-(y_2 + y_3 L_2)(z_1 + z_2) - L_3(z_3 y_3 + z_1 y_2) - (y_3 + y_4)(z_3 - L_2 z_1)$ | $z_1(L_3 y_2 - y_4 L_2) + y_3(L_3 z_3 + L_2 z_2)$ | ag det A _I | |
| Ĥ | $y_3(L_2 z_2 + L_3 z_3) + z_1(y_2 L_3 - y_4 L_2)$ | $\{ [z_1 + z_2][y_2(L_1 - L_4) + L_2 g] + [y_3 + y_4][z_3(L_1 - L_4) - L_2 z_4] + L_3(y_2 z_4 + z_3 g) \} / a$ | $z_1(L_3 y_2 - y_4 L_2) + y_3(L_3 z_3 + L_2 z_2)$ | g det A _I | |
| î | $(y_3 z_2 - y_4 z_1)(L_1 - L_4 + a) + L_3(y_3 z_4 - z_1 g)$ | $[y_3 + y_4][(L_1 - L_4)z_1 - z_4] + [z_1 + z_2][g - y_3(L_1 - L_4)] + L_3[z_1 g - y_3 z_4]$ | $y_3 z_2(a + L_1 - L_4) - z_1 y_4(a + L_1 - L_4) + L_3(y_3 z_4 - z_1 g)$ | ag det A _I | |
| Ĥ | $-[(y_3 z_3 + y_2 z_1)(a + L_1 - L_4) + L_2(z_1 g - z_4 y_3)]$ | $y_3[z_3(L_1 - L_4) - L_2 z_4] + y_2[(L_1 - L_4)z_1 - z_4] + g(z_1 L_2 - z_3)$ | $(L_2 z_2 + L_3 z_3)(y_3 a + g) + (y_4 z_3 + y_2 z_1)(a + L_1 - L_4) + (L_3 y_2 - y_4 L_2)(z_1 a + z_4)$ | ag det A _I | |

Table 2

System I: Flexible Exchange Rates

Table 3
System I: Flexible Exchange Rates
Qualitative Relationships without
Order Conditions

| EXOG. ENDO. | y^p | \hat{M} | Δy_A | \hat{z}_A | \hat{p}_A | \hat{p}^e | \hat{x}^e |
|----------------|-------|-----------|--------------|-------------|-------------|-------------|-------------|
| y | 1 | + | ? | ? | ? | ? | ? |
| \hat{p} | 0 | + | ? | ? | ? | ? | ? |
| \hat{z} | 0 | ? | ? | + | ? | ? | ? |
| \hat{x} | 0 | + | - | + | ? | ? | ? |

Table 4
System I: Flexible Exchange Rates
Qualitative Relationships with
Order Conditions

| EXOG. ENDO. | y^p | \hat{M} | Δy_A | \hat{z}_A | \hat{p}_A | \hat{p}^e | \hat{x}^e |
|----------------|-------|-----------|--------------|-------------|-------------|-------------|-------------|
| y | 1 | + | + o) | - i) | + | - | + |
| \hat{p} | 0 | + | + o) | - i) | + | + | + |
| \hat{z} | 0 | - | + | + | + | + i) | + |
| \hat{x} | 0 | + | - | + | - | + i) | + |

o) L_4 relatively small i) additional order conditions which follow from table 2

From Table 2 the dependence of the endogenous variables on the potential output y^p is omitted. But from the whole structure the dependence is obvious: y^p only influences the actual output y with a factor of 1. Tables 3 and 4 contain the influence of y^p on all endogenous variables.

Checking carefully the combinations of coefficients in each cell of Table 2, exogenous variables can be put together in an economic sense, to obtain the following four reduced forms in the four endogenous variables of System I (Flexible Exchange Rates):

$$(13) \quad y = y^p + \alpha_1(\hat{M} - \hat{P}^e) + \alpha_2(\hat{x}^e - \hat{P}^e + \hat{P}_A) + \alpha_3 \Delta y_A - \alpha_4 \hat{i}_A$$

$$(14) \quad \hat{P} = \hat{P}^e + \beta_1(\hat{M} - \hat{P}^e) + \beta_2(\hat{x}^e - \hat{P}^e + \hat{P}_A) + \beta_3 \Delta y_A - \beta_4 \hat{i}_A$$

$$(15) \quad \hat{i} = -\gamma_1(\hat{M} - \hat{P}^e) + \gamma_2(\hat{x}^e - \hat{P}^e + \hat{P}_A) + \gamma_3 \Delta y_A + \gamma_4 \hat{i}_A$$

$$(16) \quad \hat{x} = \hat{x}^e + \delta_1(\hat{M} - \hat{P}^e) - \delta_2(\hat{x}^e - \hat{P}^e + \hat{P}_A) - \delta_3 \Delta y_A + \delta_4 \hat{i}_A$$

where all α , β , γ and $\delta > 0$ and can be read from Table 2.

For example:

$$\alpha_1 = \frac{(y_3 + y_4)z_3 + (z_1 + z_2)y_2}{\text{ag det } A_I}$$

Some remarks concerning the reduced forms (13) to (16) are necessary. First, some comments on equation (13). Real output y rises in equilibrium by the same amount as the potential output which is attainable according to the real productive resources. Nominal money growth \hat{M} only effects real output as long as the expected inflation rate deviates from the money growth rate. With rational expectations this will happen only when there is unanticipated money growth.

The next three terms with coefficient α_2 , α_3 and α_4 in equation (13) are due to the connection of the home country with foreign countries. If the expected change in the exchange rate differs from the expected international inflation differences (where \hat{P}_A^e is assumed to be \hat{P}_A) then a real effect on the home economy can happen. This is called a purchasing power parity effect (ppp-effect for short). Contrary to the structural equation (2) the expected growth rate of the exchange rate in equation (13) now shows a positive influence on real output. This is not a contradiction because equation (13) shows an equilibrium condition while equation (2) is a behavioral statement. Put it differently: with a flexible exchange rate system an expected devaluation leads to an actual devaluation in equilibrium (see equation (16)). The devaluation of actual x (which is an endogenous variable) leads to an increase in real

output if inflationary differentials lag behind. Therefore the positive sign of α_2 in (13) is correct.

The other two influences on y , the real income variation abroad (Δy_A) and the movement of the interest rate abroad (\hat{i}_A) must be interpreted carefully. Although equation (13) shows a positive influence of the two variables mentioned, there could be no such influence for a long period. In a complete two country model (opposed to ours, where we deal only with one country and take the rest of the world as given) where y_A and i_A are endogenous variables themselves the effect in total equilibrium for both countries would diminish. In our presented model it must be considered that an increase in both y_A (direct positive effect on exports) and i_A (indirect positive effect on exports via a negative international capital flow effect on the exchange rate) temporarily increase real output and prices at home as well (equation (14)). This price increase (above the money growth rate) can be viewed as an effect on prices due to an increase in international incomes. Home goods demanded increase relatively to home goods produced (y^P or y^S). The increase in the domestic inflation rate will be observed and expected. The increase in \hat{P}^e then diminishes the positive effect of an increase in y due to Δy_A and \hat{i}_A .

Equation (14) shows the determination of the domestic inflation rate. In the absence of a ppp-effect and an unanticipated money growth effect the actual inflation rate will increase whenever the expected inflation rate increases. According to the rational expectation argument this will happen when the expected money supply growth

increases. A deviation from purchasing power parity ($\hat{x}^e > \hat{P}^e - \hat{P}_A$) or an unanticipated money growth ($\hat{M} > \hat{P}^e = \hat{M}^e$, where M^e is the expected money growth rate) can lead to an overshooting of the actual inflation rate relative to the expected one. In equilibrium actual and expected inflation rates are identical.

The influence of the international variables y_A and i_A on the domestic inflation rate must be viewed in the same line as in the case of the real output in equation (13). The arguments made above are valid again. Additionally an increase in the world inflation rate \hat{P}_A (or expected world inflation rate \hat{P}_A^e) does not have any impact (in equilibrium) on the domestic inflation rate, provided the flexible exchange rate system works perfectly and the increase in \hat{P}_A relative to \hat{P}^e is compensated by an equal decrease in the expected and therefore the actual exchange rate.

The behavior of the home interest rate (equation (15)) can be attributed to domestic and foreign influences as well. First, the change in the domestic interest rate only varies when there is unexpected money growth. An initial money growth rate \hat{M} above expected inflation reduces the interest rate growth. With increases in actual and expected inflation rates the interest rate returns to its previous growth rate. The other elements in (15) are the ppp-effect and again international movements in y_A and i_A .

In our structural equations we did not consider the difference between real and nominal interest rates. This leads to the conclusion that a change in the anticipated

inflation rate has no effect on the change in the interest rate (equation (15)) as long as there is no unanticipated money growth effect and a ppp-effect. If we would have distinguished between real and nominal interest rates in the structural equations (a real interest rate in equation (2) and a nominal in equation (4)) there would be a positive effect of a change in the change of the expected price level on the change of the interest rate, e.g., $\partial \hat{i} / \partial [d \hat{P}^e / dt] > 0$.

Equation (16) describes the equilibrium behavior of the actual exchange rate. Given that there is no unanticipated money growth and the purchasing power parity holds exactly (and ignoring the influence of foreign income and interest rate variation) actual exchange rates growth varies directly with its expected value. Disturbances due to unexpected money growth or unexpected ppp-effects lead to overshootings or undershootings ($\hat{x} \lessgtr \hat{x}^e$) depending on the direction of the disturbance factors. If for example transactors form their exchange rate expectations according to the ppp-theory, i.e., $\hat{x}^e = f(\hat{P}^e - \hat{P}_A^e)$, but underpredict the inflationary gap ($\hat{x}^e < \hat{P}^e - \hat{P}_A^e$), actual exchange rates growth \hat{x} will differ from the expected one and overshootings result. On the other hand an unanticipated money growth with a positive magnitude ($\hat{M} > \hat{P}^e = \hat{M}^e$) leads to a greater devaluation of the home currency than expected. Besides the portfolio and wealth effects of a money growth increase there is an other channel through which (unanticipated) monetary policy can be transmitted: that is a stimulus for exports through an increase in the actual exchange rate. This

effect, of course, is only temporary or short run and will vanish when anticipations turn out to be correct. Therefore in short, whenever there is an unanticipated money growth or an incorrect ppp-expectation, the actual exchange rates growth will deviate from the expected one.

3.3. Fixed Exchange Rates System

In a fixed exchange rates system the actual exchange rate is a parameter of the political institutions. The exogenously determined exchange rate \bar{x} turns out to be an equilibrium value only by chance. Therefore in equation (7) the balance of payments show in general an inflow or an outflow of foreign assets held by the central bank (ΔFA). The variation of the foreign assets held at the central bank in turn can lead to a proportional movement of the money supply (M^S). The actual impact of ΔFA on M^S is the result of an other political decision. If the central bank does not react to a variation in ΔFA this will influence M^S in the same direction. But the central bank can react in moving the domestic component of the money supply (DA) in the opposite direction. This is known as offsetting behavior. Surely there are limitations to this kind of policy (given the fixed exchange rates) depending on the seize and the direction of ΔFA . If it is assumed that the central bank totally and exactly offsets the foreign component of the money supply by properly choosing the domestic policy instruments (e.g., required reserve ratios) and further if it is assumed that the central bank in fact can do so, the system of fixed exchange rates becomes formally identical with the system of dirty floating discussed below and the money supply can be treated as exogenous. If it is instead assumed that the central bank does not want to or is not able to offset the foreign components FA by appropriate variations of DA , the money supply becomes endogenous (at least partly). In this section we follow the last approach and assume that movements in foreign assets

induced by the exogenously fixed, non-equilibrium exchange rate (where the equilibrium value of x is defined as x^* yielding $\Delta FA = 0$ as in the flexible case) lead to an increase or a decrease of the money supply.

In doing so a technical problem arises, because both the first difference and the absolute value of foreign assets (ΔFA and FA) appear in the equation system (1) to (7). By totally differentiating the system there will be growth rates of ΔFA and FA as well. To overcome this problem we assume that the growth rate of the balance of payments residual ($\Delta \hat{FA}$) directly influences the growth of the money supply (\hat{M}^S) rather the growth rate of the accumulated foreign assets (\hat{FA}) which would be the correct setting. The possible difference may be represented in the coefficient M_2^S of the M^S equation (5).

With these remarks in mind our model for the fixed exchange rates system may be presented in the matrix form below, where again equations (1) to (9) and (11) are totally differentiated (see the same procedure in handling the flexible exchange rates system) and terms are rearranged (Table 5).

Table 5
System II: Fixed Exchange Rates

$$\begin{pmatrix} 1 & -\frac{1}{a} & 0 & 0 & 0 \\ 1 & y_3/g & y_2/g & 0 & 0 \\ -(L_1-L_4) & -1 & L_2 & 1 & 0 \\ 0 & 0 & 0 & 1 & -M_2^S \\ z_4 & z_1 & -z_3 & 0 & 1 \end{pmatrix} \begin{pmatrix} y \\ \hat{p} \\ \hat{x} \\ \hat{M} \\ \Delta \hat{FA} \end{pmatrix} = \begin{pmatrix} 1 & 0 & -\frac{1}{a} & 0 & 0 & 0 & 0 & 0 \\ 1 & \frac{y_3+y_4}{g} & 0 & y_3/g & -y_4/g & y_5/g & 0 & 0 \\ -(L_1-L_4) & L_3 & 0 & 0 & -L_3 & L_4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & M_1^S \\ z_4 & z_1+z_2 & 0 & z_1 & -z_2 & z_4 & -z_3 & 0 \end{pmatrix} \begin{pmatrix} y^p \\ \hat{x} \\ \hat{p}^e \\ \hat{p}_A \\ \hat{x}^e \\ \Delta y_A \\ \hat{z}_A \\ \hat{DA} \end{pmatrix}$$

$$\begin{array}{ccc} A_{II} & \times & Y_{II} \\ 5 \times 5 & & 5 \times 1 \end{array} = \begin{array}{ccc} B_{II} & \times & Z_{II} \\ 5 \times 8 & & 8 \times 1 \end{array}$$

The main determinant of the coefficient matrix is

$$\det A_{II} = \frac{1}{ag} \left[(L_2 + M_2^S Z_3)(g + ay_3) + y_2(a(1 + M_2^S Z_1) + M_2^S Z_4 + L_1 - L_4) \right]$$

and is positive because of $L_1 - L_4 > 0$. Using Cramer's rule Table 6 emerges which contains the dependence of the 5 endogenous variables in the fixed exchange rate system on the 8 exogenous variables. Again the relationship between the potential output y^D and the endogenous variables is zero except for the actual output, where the coefficient is one. This dependence on y^D is omitted from Table 6.

Without order conditions the qualitative relationship turns out to be almost indetermined (Table 7). Assuming again (see system I) that Z_1 and Z_4 (that are the elasticity of the balance of payments with respect to the purchasing power parity effect and the long-run impact of real income home and abroad, respectively) are sufficiently small, most of the signs of the coefficients become determined (Table 8).

| EOG. END. | \hat{X} | \hat{P}^e | \hat{P}_A | \hat{X}^e | TO BE DIVIDED BY |
|-------------------|---|---|--|---|------------------------------|
| \hat{Y} | $y_2(z_1 M_2^s + z_2 M_2^s - L_3)$ $+ (L_2 + z_3 M_2^s)(y_3 + y_4)$ | $- [y_2(1 + M_2^s z_1)$ $+ y_3(L_2 + M_2^s z_3)]$ | $M_2^s(y_2 z_1 + y_3 z_3)$ $+ y_3 L_2$ | $- [y_4(M_2^s z_3 + L_2)$ $+ y_2(M_2^s z_2 - L_3)]$ | $ag \times$ $\det A_{II}$ |
| \hat{P} | $y_2(z_1 M_2^s + z_2 M_2^s - L_3)$ $+ (L_2 + z_3 M_2^s)(y_3 + y_4)$ | $y_2(M_2^s z_4 + L_1 - L_4)$ $+ g(L_2 + M_2^s z_3)$ | $M_2^s(y_2 z_1 + y_3 z_3)$ $+ y_3 L_2$ | $- [y_4(M_2^s z_3 + L_2)$ $+ y_2(M_2^s z_2 - L_3)]$ | $g \det A_{II}$ |
| \hat{z} | $(y_3 + y_4)(a + L_1 - L_4 + M_2^s(a z_1 + z_4))$ $- (g + a y_3)(M_2^s(z_1 + z_2) - L_3)$ | $g(1 + M_2^s z_1) - y_3(M_2^s z_4 + L_1 - L_4)$ | $- M_2^s z_1 g + y_3(a + L_1 - L_4 + M_2^s z_4)$ | $- [y_4(a + L_1 - L_4 + M_2^s(z_4 + z_1 a))$ $+ (L_3 - z_2 M_2^s)(g + y_3 a)]$ | $ag \cdot$ $\det A_{II}$ |
| \hat{M} | $[(z_1 + z_2)(y_2(a + L_1 - L_4) + L_2(a y_3 + g))$ $+ (y_3 + y_4)(z_3 a + L_1 - L_4 - z_4 L_2 - z_1 L_2 a)$ $+ y_2 L_3(z_1 a + z_4) + L_3 z_3(y_3 a + g)] M_2^s$ | $[L_2(y_3 z_4 - z_1 g)$ $- (L_1 - L_4)(y_3 z_3 + y_2 z_1)$ $+ y_2 z_4 + g z_3] M_2^s$ | $[z_1(L_2 g + y_2 a) + (y_3 z_3 + z_1 y_2)$ $(L_1 - L_4) + y_3(z_3 a - L_2 z_4)] M_2^s$ | $- M_2^s[(y_2 z_2 + y_4 z_3)(a + L_1 - L_4)$ $+ (y_2 L_3 - y_4 L_2)(z_1 a + z_4)$ $+ (g + y_3 a)(L_2 z_2 + L_3 z_3)]$ | $ag \cdot$ $\det A_{III}$ |
| $\hat{\Delta FA}$ | $(z_1 + z_2)(L_2(g + a y_3) + y_2(a + L_1 - L_4))$ $+ (y_3 + y_4)(z_3(a + L_1 - L_4) - L_2(z_1 a + z_4))$ $+ L_3(y_2(a z_1 + z_4) + z_3(g + y_3 a))$ | $L_2(y_3 z_4 - z_1 g)$ $- (L_1 - L_4)(y_3 z_3 + y_2 z_1)$ $+ y_2 z_4 + g z_3$ | $z_1(L_2 g + y_2 a)$ $+ (y_3 z_3 + z_1 y_2)(L_1 - L_4)$ $+ y_3(z_3 a - L_2 z_4)$ | $- [(y_2 z_2 + y_4 z_3)(a + L_1 - L_4)$ $+ (y_2 L_3 - y_4 L_2)(z_1 a + z_4)$ $+ (g + y_3 a)(L_2 z_2 + L_3 z_3)]$ | $ag \cdot$ $\det A_{II}$ |

Table 6

System II: Fixed Exchange Rates

| | Δy_A | \hat{z}_A | \hat{D}_A | TO BE DIVIDED BY |
|-------------------|---|---|---|------------------------|
| y | $y_2 (z_4 M_2^s - L_4)$ $+ y_5 (z_3 M_2^s + L_2)$ | $- z_3 y_2 M_2^s$ | $M_2^s y_2$ | ag $\det A_{II}$ |
| \hat{p} | $y_2 (z_4 M_2^s - L_4)$ $+ y_5 (z_3 M_2^s + L_2)$ | $- z_3 y_2 M_2^s$ | $M_2^s y_2$ | $g \det A_{II}$ |
| \hat{z} | $ay_3 (L_4 - z_4 M_2^s)$ $+ y_5 (L_1 - L_4 + M_2^s z_4 + a(1 + z_1))$ $+ g(z_4 + L_4)$ | $M_2^s z_3 [g + ay_3]$ | $- M_2^s [g + ay_3]$ | ag $\det A_{II}$ |
| \hat{M} | $M_2^s [(y_2 z_4 + y_5 z_3)(a + L_1 - L_4)$ $+ (z_3 L_4 + L_2 z_4)(g + ay_3)$ $+ (z_1 a + z_4)(y_2 L_4 - y_5 L_2)]$ | $- M_2^s z_3 [L_2 (g + y_3 a) + y_2 (L_1 - L_4 + a)]$ | $M_2^s [L_2 (g + ay_3) + y_2 (a + L_1 - L_4)]$ | ag $\det A_{II}$ |
| $\hat{\Delta FA}$ | $(y_2 z_4 + y_5 z_3)(a + L_1 - L_4)$ $+ (z_3 L_4 + L_2 z_4)(g + ay_3)$ $+ (z_1 a + z_4)(y_2 L_4 - y_5 L_2)$ | $- z_3 [L_2 (g + y_3 a) + y_2 (L_1 - L_4 + a)]$ | $- M_2^s [z_3 (y_3 a + g) + y_2 (z_4 + z_1 a)]$ | ag $\det A_{II}$ |

Table 6 (cont.)

System II: Fixed Exchange Rates

Table 7
System II: Fixed Exchange Rates
Qualitative Relationships without
Order Conditions

| EXCH. END. | y^p | \hat{x} | \hat{p}^e | \hat{p}_A | \hat{x}^e | Δy_A | \hat{z}_A | \hat{d}_A |
|---------------|-------|-----------|-------------|-------------|-------------|--------------|-------------|-------------|
| y | 1 | ? | - | + | ? | ? | - | + |
| \hat{p} | 0 | ? | + | + | ? | ? | - | + |
| \hat{z} | 0 | ? | ? | ? | ? | ? | + | - |
| \hat{M} | 0 | ? | ? | ? | ? | ? | - | + |
| ΔFA | 0 | ? | ? | ? | ? | ? | - | - |

Table 8
System II: Fixed Exchanges Rates
Qualitative Relationships with
Order Conditions

| EXCH. END. | y^p | \hat{x} | \hat{p}^e | \hat{p}_A | \hat{x}^e | Δy_A | \hat{z}_A | \hat{d}_A |
|---------------|-------|-----------|-------------|-------------|-------------|--------------|-------------|-------------|
| y | 1 | + o) | - | + | - i) | + w) | - | + |
| \hat{p} | 0 | + o) | + | + | - i) | + h) | - | + |
| \hat{z} | 0 | ? | ? | + | ? | + | + | - |
| \hat{M} | 0 | + | ? | + | - | + | - | + |
| ΔFA | 0 | + | ? | + | - | + | - | - |

- o) $y_2 L_3 < y_2 Z_1 M_2^S + Z_2 M_2^S y_2 + (L_2 + Z_3 M_2^S)(y_3 + y_4)$
i) L_3 not too great or o) is valid
h) L_4 not too great

Equations (17) to (21) below are the reduced forms of system II for the endogenous variables y , P , i , M and $\Delta \hat{FA}$.

$$(17) \quad y = y^p + y_2(M_1^s \hat{DA} - \hat{P}^e) + \alpha_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \alpha_3(\hat{x} - \hat{x}^e) + \alpha_4 \Delta y_A - \alpha_5 \hat{i}_A$$

$$(18) \quad \hat{P} = \hat{P}^e + y_2(M_1^s \hat{DA} - \hat{P}^e) + \beta_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \beta_3(\hat{x} - \hat{x}^e) + \beta_4 \Delta y_A - \beta_5 \hat{i}_A$$

$$(19) \quad \hat{i} = -(g+ay_3)(M_1^s \hat{DA} - \hat{P}^e) + \gamma_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \gamma_3(\hat{x} - \hat{x}^e) + \gamma_4 \Delta y_A + \gamma_5 \hat{i}_A$$

$$(20) \quad \hat{M} = M_1^s \hat{DA} - \int_1 (M_1^s \hat{DA} - \hat{P}^e) + \int_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \int_3(\hat{x} - \hat{x}^e) + \int_4 \Delta y_A + \int_5 \hat{i}_A$$

$$(21) \quad \Delta \hat{FA} = -\xi_1(M_1^s \hat{DA} - \hat{P}^e) + \xi_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \xi_3(\hat{x} - \hat{x}^e) + \xi_4 \Delta y_A - \xi_5 \hat{i}_A$$

The reduced forms of system II: Fixed Exchange Rates, equations (17) to (21), show some similarities with the reduced forms (13) to (16) of system I. The similarities

consist of the same general direction of the unexpected money growth, the PPP-effect and the influence of foreign real income and interest rate changes on domestic real income, inflation rate and interest rate change, respectively. Differences due to the exchange rate system are the following.

First, there is no equilibrium condition for the actual exchange rate movement \hat{x} in the fixed rate system and therefore no reduced form for \hat{x} like equation (16) in the flexible rate system. Second, both the money supply growth M and the balance of payments movement ΔFA are endogenous in system II. Equation (20) and (21) emerge as the reduced forms. Equation (20) shows that the monetary authority can influence the money supply growth by varying the domestic component of the money supply DA . If the elasticity of the money supply M^S with respect to the domestic part DA is close to one ($M_1^S = 1$), the movement of M will follow exactly the movement of DA (ceteris paribus). Equation (20) also shows that besides the monetary policy instrument other influences determine the growth rate of the money supply. Taking M_1^S equal to 1 for the moment there will be a higher money growth if expected prices (or expected money growth) are higher than the actual influence of the domestic part on the money supply. The reasons are as follows. A higher expected inflation rate (above the actual rate) leads to a reduction of the real output supplied (equation (1)). The real income at home relative to the real income abroad can induce a reduction in the demand for foreign currencies (equation (7)). The balance of payments improves and the foreign component of the money supply increases.

Moreover a negative unexpected money growth ($M_1^S \hat{DA} < \hat{P}^e = \hat{DA}^e$) leads to an increase in the domestic interest rate growth (equation (19)) which again increases $\Delta \hat{FA}$ through the interest rate effect on the balance of payments and therefore another source for increases in the foreign component of the money supply is established. Both endogenous effects (income effect and interest rate effect) on the balance of payments are incorporated in the first expression on the right hand side of equation (21).

Another and very important divergence between the flexible and the fixed rate system is an additional major channel in the fixed exchange rate system through which international disturbances can influence the home economy. All endogenous variables in system II show a positive dependency on unexpected exchange rate movements ($\hat{x} - \hat{x}^e$). Therefore in periods of international monetary disorder disturbing effects not only emerge through a possible ppp-effect ($\hat{x} \neq \hat{P}^e - \hat{P}_A$) but also through an expectation effect ($\hat{x} \neq \hat{x}^e$), not necessarily of the same direction and magnitude. But if exchange rate expectations are oriented on the expected inflation rates home and abroad while the actual exchange rate is fixed, both effects are of the same direction and the total impact on y (or the other endogenous variables) is greater than for example in the flexible exchange rate system where it is only the ppp-effect which is relevant. Moreover, if there is no ppp-effect (because of $\hat{x} = \hat{P}^e - \hat{P}_A$ or $\alpha_2 = \beta_2 = \gamma_2 = \delta_2 = \xi_2 = 0$) but expected exchange rate movements are based on other relative international economic or political variables, there can be still a disturbing effect in the fixed exchange rate system

while there is none in the system of flexible rates. Such expectational divergencies are especially very likely in situations of extreme speculation against a currency, which actually happened in the German case quite often, for example 1958/60, 1968/69 and in the period after 1973 (managed floating).

3.4. Dirty Floating System

A dirty floating system is based on the assumption that the official authorities determine exogenously to which extent external disequilibria may effect ΔFA and/or x . In general we obtain the same real effects in this version of the model as in the fixed rate system. The difference from system II: Fixed Exchange Rates is due to the politically controllable variables ΔFA and \bar{x} and therefore the more or less exogeneity of M^S in the dirty floating system. The fact must be stressed however that the central bank can only control one variable at the time, that is ΔFA (and therefore M^S) or x . But the public is never sure which instrument at which time the central bank chooses. The result is in general an unexpected shift between properties of the flexible rate system ($\Delta FA = \text{constant}$ and x variable) and the fixed rate system ($x = \text{constant}$ and ΔFA variable).

In view of our model for the dirty floating system we assume that both ΔFA and x are controllable and manageable one at a time by the central bank and we therefore treat both ΔFA and x as politically determined and fixed. As a consequence of this procedure equation (7) disappears from our equation system and Fa and x are set as \bar{FA} and \bar{x} , respectively. System III: Dirty or managed floating can be written in matrix form with

Table 9
System III: Dirty Floating

$$\begin{bmatrix} 1 & -\frac{1}{a} & 0 \\ 1 & y_3/g & y_2/g \\ -(L_1-L_4) & -1 & L_2 \end{bmatrix} \times \begin{bmatrix} y \\ \hat{p} \\ \hat{i} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & -\frac{1}{a} & 0 & 0 \\ 1 & 0 & y_5/g & y_3/g & 0 & \frac{y_3+y_4}{g} & -\frac{y_4}{g} \\ -(L_1-L_4) & -1 & L_4 & 0 & 0 & L_3 & -L_3 \end{bmatrix} \times \begin{bmatrix} y^p \\ \hat{M} \\ \Delta y_A \\ \hat{p}_A \\ \hat{p}_e \\ \hat{x} \\ \hat{x}^e \end{bmatrix}$$

$$\begin{array}{ccc} A_{III} & \times & Y_{III} \\ 3 \times 3 & & 3 \times 1 \end{array} = \begin{array}{ccc} B_{III} & \times & Z_{III} \\ 3 \times 7 & & 7 \times 1 \end{array}$$

the same assumptions made for systems I and II concerning the functional form of the equations and the same procedure of total differentiation.

The main determinant of the coefficient matrix A_{III} is

$$\det A_{III} = \frac{1}{ag} \left[L_2(ay_3 + g) + y_2(a + L_1 - L_4) \right] > 0$$

which is positive.

Using again Cramer's rule Table 10 is worked out. With no order conditions the qualitative relationships between the three endogenous variables y , \hat{P} and \hat{i} and the 7 exogenous variables (y^p , \hat{M} , Δy_A , \hat{P}_A , \hat{P}^e , \hat{x} and \hat{x}^e) are shown in Table 11. If it is assumed that the reaction of the demand for real balances is relatively small with respect to y/y_A and x/x^e (that is L_3 and L_4 sufficiently small, not necessarily zero) than Table 12 can be deduced.

From Table 10 the three reduced forms (22) to (24) are extracted, where the positive signs of the parameters follow from the assumptions made above and in Table 12.

| EXOD. END. | y^p | \hat{M} | Δy_A | \hat{P}_A | \hat{P}^e | \hat{x} | \hat{x}^e | TO BE DIVIDED BY |
|---------------|-------|---------------|---------------------------------------|----------------------|--------------------------------|---|--|---------------------|
| y | 1 | y_2 | $y_5 L_2 - y_2 L_4$ | $L_2 y_3$ | $-(y_3 L_2 + y_2)$ | $L_2(y_3 + y_4) - y_2 L_3$ | $y_2 L_3 - y_4 L_2$ | $ag \det A_{III}$ |
| \hat{P} | 0 | y_2 | $y_5 L_2 - y_2 L_4$ | $L_2 y_3$ | $[y_2(L_1 - L_4) + L_2 g] / a$ | $L_2(y_3 + y_4) - y_2 L_3$ | $y_2 L_3 - y_4 L_2$ | $g \det A_{III}$ |
| \hat{c} | 0 | $-[ay_3 + g]$ | $L_4(g + y_3 a) + y_5(a + L_1 - L_4)$ | $y_3(a + L_1 - L_4)$ | $-[y_3(L_1 - L_4) - g]$ | $L_3(g + ay_3) + (y_3 + y_4)(L_1 - L_4)a$ | $-L_3(g + y_3 a) - y_4(a + L_1 - L_4)$ | $ag \det A_{III}$ |

Table 10
System III: Dirty Floating

Table 11
System III: Dirty Floating
Qualitative Relationships without
Order Conditions

| EXOG. END. | y^p | \hat{M} | Δy_A | \hat{p}_A | \hat{p}_e | \hat{x} | \hat{x}^e |
|---------------|-------|-----------|--------------|-------------|-------------|-----------|-------------|
| y | 1 | + | ? | + | - | ? | ? |
| \hat{p} | 0 | + | ? | + | + | ? | ? |
| \hat{z} | 0 | - | + | + | ? | + | - |

Table 12
System III: Dirty Floating
Qualitative Relationships with
Order Conditions

| EXOG. END. | y^p | \hat{M} | Δy_A | \hat{p}_A | \hat{p}_e | \hat{x} | \hat{x}^e |
|---------------|-------|-----------|--------------|-------------|-------------|-----------|-------------|
| y | 1 | + | + | + | - | + | - |
| \hat{p} | 0 | + | + | + | + | + | - |
| \hat{z} | 0 | - | + | + | ? | + | - |

$$(22) \quad y = y^D + \alpha_1(\hat{M} - \hat{P}^e) + \alpha_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \alpha_3(\hat{x} - \hat{x}^e) + \alpha_4 \Delta y_A$$

$$(23) \quad \hat{P} = \hat{P}^e + \beta_1(\hat{M} - \hat{P}^e) + \beta_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \beta_3(\hat{x} - \hat{x}^e) + \beta_4 \Delta y_A$$

$$(24) \quad i = -\gamma_1(\hat{M} - \hat{P}^e) + \gamma_2(\hat{x} - \hat{P}^e + \hat{P}_A) \\ + \gamma_3(\hat{x} - \hat{x}^e) + \gamma_4 \Delta y_A$$

The interpretation of equations (22) to (24) is very similar to the corresponding reduced forms of system II, that is equations (17) to (19). The only difference exists between the exogenous \hat{M} in system III whereas $M_1^{S\hat{D}A}$ is the exogenous part of the money supply in the fixed rate system. Again the difference to the system with flexible exchange rates stems from the additional expectational effect $\hat{x} - \hat{x}^e$. The arguments made in the previous chapter are valid here as well.

4. Empirical Example: The Influence of Unanticipated
Monetary Variables on Real GNP and Employment:
The German Case 1960 - 1977

4.1. Introduction and Test Equations

The theoretical model of part 3 leads to testable reduced forms. In an empirical investigation we test a compromised version of the general model outlined above. For simplicity we assume that several postulated dependencies do not exist:

- The demand for real output, the demand for real money and therefore the balance of payments is not sensitive to the relative movement of domestic to foreign real income.
- The balance of payments is not sensitive to the relative movements of domestic and foreign interest rates.

That is,

$$(25) \quad y_5^d = L_4 = Z_3 = Z_4 = 0$$

In the empirical part we also concentrate on the explanation of real GNP and consequently of the employment rate. For the three exchange rate systems we get two reduced forms (26) and (27) for the real output y and (28) and (29) for the employment rate ($1-u$, where u is the unemployment rate) by taking (25) in account.

We treat both reduced forms for the fixed exchange rate system and the dirty floating system as equivalent in assuming that the growth of the domestic part (\hat{DA}) of

the money supply growth (\hat{M}) in the fixed exchange rate system is equal to the growth rate of the money supply itself. Therefore it is assumed that the elasticity of the money supply with respect to the domestic controllable part is 1 or the central bank is able to and actually does offset movements in the foreign money supply component (FA).

To get the reduced form for $(1-u)$ we set

$$(1-u) = f(\dots, y, \dots) \text{ and}$$

$$(1-u^*) = g(\dots, y^p, \dots).$$

This procedure was explained in part 3, section 1 above.

As our model does not explain the potential output y^p (or the natural rate of unemployment u^*) we approximate the former by a linear trend and the latter by a constant term for the empirical investigation.

In addition to the theoretical part we allow a dynamic lag pattern for the exogenous variables to influence real GNP (or $1-u$).

Reduced Forms for Testing:

A. Real Output

1. Flexible Exchange Rates

$$(26) \quad y_t = \alpha_{01}^y + \alpha_{02}^y t + \alpha_{1j}^y (\hat{M} - \hat{P}^e)_{t-j} \\ + \alpha_{2k}^y (\hat{x}^e - \hat{P}^e + \hat{P}_A)_{t-k} + v_t$$

$$j = 0, 1, \dots$$

$$k = 0, 1, \dots$$

2. Fixed Exchange Rates and Dirty Floating

$$\begin{aligned}
 (27) \quad y_t = & \beta_{01}^y + \beta_{02}^y t + \beta_{1j}^y (\hat{M} - \hat{P}^e)_{t-j} \\
 & + \beta_{2k}^y (\hat{x} - \hat{P}^e + \hat{P}_A)_{t-k} \\
 & + \beta_{3m}^y (\hat{x} - \hat{x}^e)_{t-m} + v_t
 \end{aligned}$$

$$j = 0, 1, \dots; \quad k = 0, 1, \dots; \quad m = 0, 1, \dots;$$

B. Employment Rate

1. Flexible Exchange Rates

$$\begin{aligned}
 (28) \quad (1-u) = & \alpha_0^u + \alpha_{1j}^u (\hat{M} - \hat{P}^e)_{t-j} \\
 & + \alpha_{2k}^u (\hat{x}^e - \hat{P}^e + \hat{P}_A)_{t-k} + v_t
 \end{aligned}$$

$$j = 0, 1, \dots; \quad k = 0, 1, \dots;$$

2. Fixed Exchange Rates and Dirty Floating

$$\begin{aligned}
 (29) \quad (1-u) = & \beta_0^u + \beta_{1j}^u (\hat{M} - \hat{P}^e)_{t-j} \\
 & + \beta_{2k}^u (\hat{x} - \hat{P}^e + \hat{P}_A)_{t-k} + \beta_{3m}^u (\hat{x} - \hat{x}^e)_{t-m} \\
 & + v_t
 \end{aligned}$$

$$j = 0, 1, \dots; \quad k = 0, 1, \dots; \quad m = 0, 1, \dots;$$

4.2. Computation of Expected Values

To test the equations (26) to (29) (formulated in the previous section and directly derived from the reduced forms of our model in section 3), we need to compute the two expected values \hat{M}_t^e and \hat{x}_t^e . We assume that the expectations of the money supply growth rate \hat{M}_t^e are formed by a transactor who watches the actual growth rate of M in the past (\hat{M}_{t-i_1}) and who also bases his expectations on a hypothesis about the behavior of the German Central Bank. As a consequence of such a "rational" explanation of the formation of expectations, \hat{M}_t^e depends on the following arguments:

$$(30) \quad \hat{M}_t^e = h(\hat{M}_{t-i_1}, \hat{P}_{t-i_2}, i_{t-i_3}^s, u_{t-i_4}, \hat{FA}_{t-i_5})$$

$$\text{with } h_1, h_3, h_4 > 0 \quad \text{and} \quad h_2, h_5 < 0.$$

Economic agents involved in the process of forming expectations about the central bank's behavior receive relevant information through legal prescriptions, empirical observations and announcements of the Deutsche Bundesbank (DBB). The DBB is legally required to take special account of general economic goals like price stability, full employment and equilibrium in the balance of payments⁷⁾. This is reflected in the arguments of equation (30).

The transactor can assume that the DBB reacts by reducing money growth if both the inflation rate \hat{P}_{t-i_2} and the official currency reserves \hat{FA}_{t-i_5} have increased. This is expressed in the negative signs of h_2 and h_5 . In contrast, the DBB reacts positively when

observed unemployment u_{t-14} increases. It should be stressed here that the inclusion of u_{t-14} is not consistent with our hypothesis that the employment rate depends mainly on unanticipated growth rates of M^S . If the central bank reacts systematically when u_{t-14} increases and if the economic agents consider this policy explicitly in their \hat{M}_t^e -expectations, it follows that in contradiction to our hypothesis u is an argument to explain \hat{M}_t^e . In the context of our rational expectations-hypothesis we therefore leave out u_{t-14} as an argument of the \hat{M}_t^e - function.

To understand the meaning of the argument i_{t-13}^S , it should be noted that one of the most important aims of the German central bank was the control of bank liquidity.⁸⁾ A high level of i^S (which is defined as a short term interest rate) signals a shortage in the money market (where only banks are market participants) and a low level of bank liquidity. In this case the central bank will increase the money supply ($h_3 > 0$).

In the process of forming his expectations of the money growth, the rational transactor also needs information about the relative importance of the various arguments cited above. For the computation of our \hat{M}_t^e - time - series we therefore analysed the explanatory power of all combinations of arguments in determining M . We then used the coefficients of the regression-equation with the highest R^2 - and F - values:⁹⁾

$$(31) \quad M_t = \frac{0.47}{(2.53)} \sum_{i=1}^3 \frac{\hat{M}_{t-i}}{3} - \frac{1.19}{(2.26)} \sum_{i=1}^3 \frac{\hat{P}_{t-i}}{3} + \frac{1.51}{(3.14)} \sum_{i=1}^3 \frac{\hat{u}_{t-i}}{3}$$

$$R_{adj}^2 = 0.1598; \quad F = 3.69; \quad D.W. = 1.89$$

Equation (31) shows that M_t is best explained by the arguments $\sum_{i=1}^3 \frac{\hat{M}_{t-i}}{3}$, $\sum_{i=1}^3 \frac{\hat{P}_{t-i}}{3}$ and $\sum_{i=1}^3 \frac{i^3_{t-i}}{3}$ (for the period 1955-1977 using yearly data). If we combine this result with our hypothesis from equation (30), we can conclude that the DBB during the period, 1955-1977 stressed particularly its antiinflationary and bank liquidity policy.

There exist several possibilities in the explanation of the process of the formation of expectations about \hat{x} on a rational basis. One alternative is founded on the theory of purchasing power parity and treats exchange rates as relative prices of different national outputs. Within this older view \hat{x}^e can be approximated by the difference $(\hat{P} - \hat{P}_A)$.

In contrast to this "flow-approach" a "stock-approach" or a "stock-adjustment-view" of exchange rates regards \hat{x} as the relative price of different national currencies. As a consequence \hat{x}^e has to be based on the relative money supply growth rates at home and abroad $(\hat{M} - \hat{M}_A)$.

A third alternative refers to the forward currency market, where the future price of home currency is determined explicitly by a market process. We can assume, that the forward rate FR incorporates all information about the development of the value of home currency relative to others. For our empirical tests we therefore simply equate $\hat{x}^e = \hat{FR}$.

4.3. Empirical Results

We tested the equations (26) - (29) with yearly data for the Fed. Rep. of Germany, 1960 - 1977. The explanatory variables are lagged for a maximum of 5 years, longer lags have been resulted in insignificant parameters. Consistent data (especially for the forward rate FR) are not available for the period before 1955. This is because of the official restrictions on international capital flows in Germany in the early fifties. The underlying data are extensively described in Appendix II.

4.3.1. Real GNP

The empirical results obtained from testing equation (26) for flexible exchange rates

$$\begin{aligned}
 (32) \quad y_t = & 296.22 + 19.84 t + 0.76 (\hat{M} - \hat{M}^e)_t - 0.97 (\hat{x}^e - \hat{P} + \hat{P}_A)_t \\
 & (37.83) \quad (16.96) \quad (0.48) \quad (1.31) \\
 & + 2.21 (\hat{M} - \hat{M}^e)_{t-1} - 0.80 (\hat{x}^e - \hat{P} + \hat{P}_A)_{t-1} \\
 & (1.82) \quad (0.96) \\
 & + 0.64 (\hat{M} - \hat{M}^e)_{t-2} - 0.43 (\hat{x}^e - \hat{P} + \hat{P}_A)_{t-2} \\
 & (0.32) \quad (0.72) \\
 & + 0.68 (\hat{x}^e - \hat{P} + \hat{P}_A)_{t-3} \\
 & (0.59) \\
 & + 1.98 (\hat{x}^e - \hat{P} + \hat{P}_A)_{t-4} \\
 & (1.86) \\
 & + 0.95 (\hat{x}^e - \hat{P} + \hat{P}_A)_{t-5} \\
 & (0.46)
 \end{aligned}$$

$$R^2_{adj} = 0.9879$$

$$F = 148.55$$

$$D.W. = 1.72$$

show the expected sign for the α_{ij}^y parameters. But the t-values (in paranthesis below the parameters) for the current and two lagged periods indicate no influence from $(\hat{M}-\hat{M}^e)$ on y_t .

The same happens for the α_{2k}^y parameters, which measure the influence of $(\hat{x}^e - \hat{P} + \hat{P}_A)$. The first three parameters even have a negative sign. We therefore conclude, that during the test period no support is given to purchasing power parity theory and that the behavior of the German economy is not well described by a flexible exchange rate system. This is not surprising, because in Germany fixed rates were in existence up to 1968 with one evaluation of the DM in 1961.

We now turn to the testing equations of the models with fixed exchange rates and dirty floating which are summarized in Table 13.

For the reduced form equation of our model with assumption (25) (i.e. testing equation (32) in Table 13) we obtain the following results: the coefficients β_1^y and β_2^y are either insignificantly different from zero - as can be seen by the t-ratio - or show the theoretically wrong negative sign. Only the effect of what we called the "exchange rate expectation-effect" seemsto be of greater importance. But even here the theoretically correct signs are by no means statistically significant at an appropriate level. We can conclude that in the case of full specification of the models with fixed exchange rates and dirty floating the purchasing power parity effect is also not supported. (see Appendix 1).

Table 13

Unanticipated Monetary Variables and Their Effect on
Real GNP: Empirical Results for the Fixed Rate and
Dirty Floating System

| Number of Equation | (32) | (33) | (34) | (35) | (36) |
|-------------------------------------|-------------------|-------------------|-------------------|-------------------|----------------|
| Dependent Variable | y_t | y_t | y_t | y_t^p | $(x-y^p)_t$ |
| Constant Term | 300.30 (48.04) | 294.11 (38.14) | 291.74 (94.53) | 268.00 (26.57) | |
| Trend Variable | 18.64 (27.13) | 20.44 (17.03) | 19.88 (65.84) | 18.51 (22.54) | |
| $(\hat{M}-\hat{M}^e)_t$ | 0.79 (0.55) | 1.02 (0.74) | 3.31 (3.83) | | 0.96 (0.81) |
| $(\hat{M}-\hat{M}^e)_{t-1}$ | 1.96 (1.45) | 2.01 (1.47) | 1.78 (3.89) | | 1.84 (2.43) |
| $(\hat{M}-\hat{M}^e)_{t-2}$ | -0.09 (0.05) | 1.47 (0.74) | 3.66 (4.29) | | 0.35 (0.33) |
| $(\hat{x}-\hat{p}+\hat{p}_A)_t$ | -1.02 (1.11) | -0.10 (0.10) | | | |
| $(\hat{x}-\hat{p}+\hat{p}_A)_{t-1}$ | -3.26 (2.92) | -0.57 (0.53) | | | |
| $(\hat{x}-\hat{p}+\hat{p}_A)_{t-2}$ | 0.71 (0.67) | 0.50 (0.69) | | | |
| $(\hat{x}-\hat{p}+\hat{p}_A)_{t-3}$ | | 0.59 (0.79) | | | |
| $(\hat{x}-\hat{p}+\hat{p}_A)_{t-4}$ | | 0.96 (0.71) | | | |
| $(\hat{x}-\hat{p}+\hat{p}_A)_{t-5}$ | | 3.09 (1.30) | | | |
| $(\hat{x}-\hat{x}^e)_t$ | 2.09 (1.28) | | 5.12 (5.80) | | 3.57 (2.63) |
| $(\hat{x}-\hat{x}^e)_{t-1}$ | 5.03 (1.70) | | 8.92 (5.82) | | 5.21 (2.45) |
| $(\hat{x}-\hat{x}^e)_{t-2}$ | 4.20 (1.57) | | 3.60 (3.67) | | 3.07 (2.15) |
| $(\hat{x}-\hat{x}^e)_{t-3}$ | | | 0.87 (0.66) | | 2.31 (1.19) |
| $(\hat{x}-\hat{x}^e)_{t-4}$ | | | 13.52 (10.24) | | 8.52 (4.18) |
| $(\hat{x}-\hat{x}^e)_{t-5}$ | | | 16.62 (8.57) | | 8.61 (3.18) |
| R^2_{adj} | 0.9896 | 0.9901 | 0.9980 | 0.9878 | 0.6181 |
| F-Ratio | 172.11 | 181.23 | 902.57 | 1623.56 | 4.77 |
| DW | 1.84 | 1.80 | 1.42 | 1.49 | 2.07 |

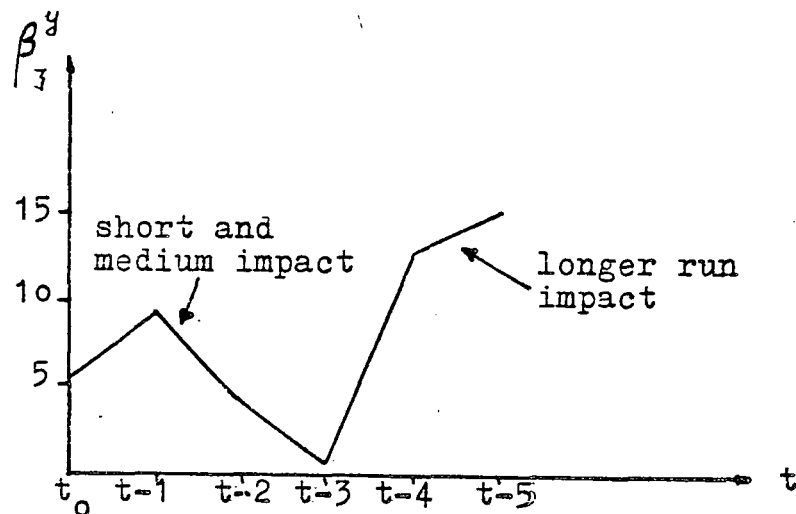
Stronger evidence for this conclusion is provided when the two effects (purchasing power parity and exchange rate expectation effects) are separated. The results are shown in the testing equations (33) and (34). The statistical quality of equation (33) (in which the purchasing power parity effect is included) does not differ significantly from the results obtained above. The high R^2 and F-ratio in the equations (31) to (33) must therefore be attributed to the strong influence of the constant and trend parameters.

For the equation that isolates the exchange rate expectation effect (i.e. equation (34) in Table 13), we get a complete different result: the estimation shows that the relevant parameters are significant, all having the expected sign. Except in the case of $(\hat{x} - \hat{x}^e)_{t-3}$, all coefficients are significant at the high 99% level. The inclusion of $(\hat{M} - \hat{M}^e)_{t-3}$ and higher lagged values results in no improvement, with the corresponding coefficients not statistically different from zero.¹⁰⁾ The obtained lags seem quite reasonable compared with standard empirical results (e.g. Barro (1977) and (1978)). On the other hand, the lag pattern is somewhat surprising: we observe a strong current influence, which decreases in $t-1$, then becomes stronger for the period $t-2$.

The results of (34) further imply that a 1% change in the unexpected growth rate of the money supply during three succeeding years has an effect on real output of about 8.8 billion DM. With an average German GNP within the testing period of 482.5 billion DM, we obtain a relative impact of about 2%.

The real effects of unexpected exchange rate movements are both stronger and longer than the analysed impact of $(\hat{M} - \hat{M}^e)_{t-1}$. The lag pattern of the β_3^y coefficients indicates two distinct groups of influences. The results suggests that we can separate the short- and medium impact (lasting from t to $t-2$ as can be seen from Fig. 1) from the longer run impact. This proposition is supported by the low statistical quality of the β_3^y parameter for $(\hat{x} - \hat{x}^e)_{t-3}$. We interpret the short-term effect as being the result of the influence of unexpected exchange rate movements on the current account balance, which changes real output directly, and of the indirect influences on y_t stemming from the reaction of the money market and especially of interest rates.

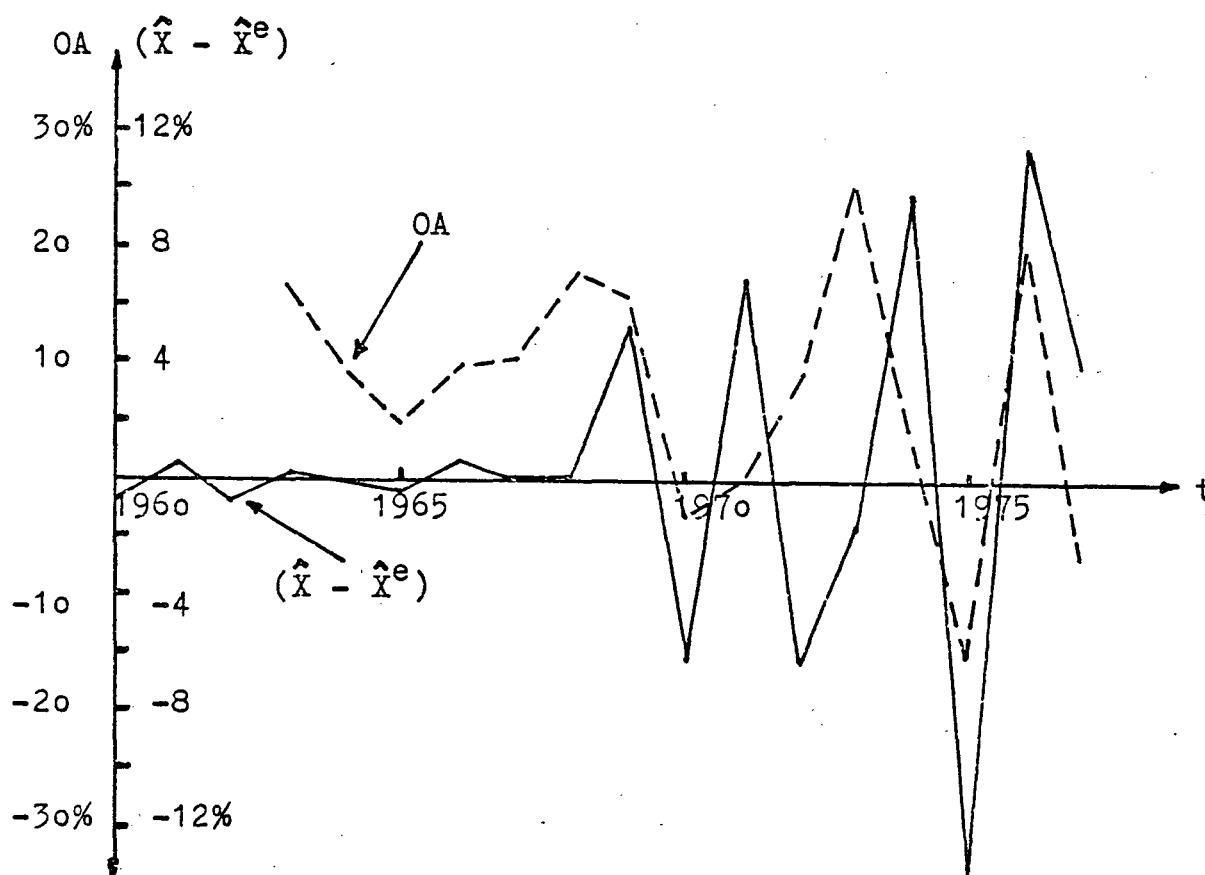
Fig. 1: β_3^y coefficient of Regression Equation (34)



The direct effect of $(\hat{x} - \hat{x}^e)$ on real output via exports and imports can be derived from Fig. 2, where $(\hat{x} - \hat{x}^e)$ and the growth in real industrial orders from abroad (OA) in general move in the same direction. Apparently, an expected appreciation of the DM leads to an increase in OA, greater real exports and therefore to an

increase in real output. An actual appreciation, in contrast, has a negative effect on real GNP.

Fig. 2: Unanticipated Exchange Rate Growth ($\hat{\bar{x}} - \hat{\bar{x}}^e$) and Growth in Real Industrial Orders from Abroad (OA) in West Germany



The second, longer run impact - shown in Fig. 1 - seems to be the result of the increasing importance of the direct investment, a special feature of the relationship

between Germany and foreign countries, particularly the U.S.. We assume, that the real effects of such direct investments occur after a longer period of time.¹¹⁾

It could be argued, that the good performance of equation (34) is mainly due to the linear trend variable. We therefore separate the effect of y^p on real output y_t from the influences caused by unanticipated monetary variables. We first approximate y^p by equation (35) in Table 13 and then take the differences between actual values of real GNP (y_t) and the y^p values, obtained from the above equation (35). In regression equation (36) of Table 13 the isolated influence of the unanticipated monetary variables is estimated. Though the R^2 and F-ratio are lower than in (34) the explanatory power of this test-formulation is still high.

4.3.2. Employment Level

The tests of the equations (28) and (29) with the employment rate $(1-u)$ as the dependent variable are only discussed for the fixed rate and dirty floating systems, leaving out the purchasing power parity effect (for further results see appendix 1). We first treat the natural rate of unemployment u^* as a constant over the whole period (see equation (37) in Table 14): the coefficients of unanticipated money growth and unexpected exchange rate movements show the same time-pattern as in the tests with real GNP. The R^2 and t-ratios, however, are lower and some coefficients are insignificant. Even after application of the Prais-Winsten procedure (Johnston, p. 264) for reducing the autocorrelation, there still seems to be positive autocorrelation (see the low D.W. statistic).

Table 14

Unanticipated Monetary Variables and Their Effects on
the Employment Level: Empirical Results for the Fixed
Rate and Dirty Floating System

| Number of Equation | (37) | (38) | (39) |
|---|-------------------|-------------------|-------------------|
| Dependent Variable | $(1-u)_t$ | $(1-u)_t$ | $(1-u)_t$ |
| Constant Term | 98.12 (374.37) | 99.44 (279.28) | 98.76 (794.79) |
| Trend Variable | | -0.14 (3.95) | |
| Dummy Variable D_{60-68} D_{69-77} | | | -1.39 (6.98) |
| $(\hat{M} - \hat{M}^e)_t$ | 0.21 (1.68) | 0.05 (0.51) | 0.13 (2.16) |
| $(\hat{M} - \hat{M}^e)_{t-1}$ | 0.07 (0.94) | 0.02 (0.40) | 0.06 (1.80) |
| $(\hat{M} - \hat{M}^e)_{t-2}$ | 0.23 (1.94) | 0.04 (0.42) | 0.10 (1.66) |
| $(\hat{x} - \hat{x}^e)_t$ | 0.34 (2.53) | 0.25 (2.32) | 0.39 (5.97) |
| $(\hat{x} - \hat{x}^e)_{t-1}$ | 0.68 (2.85) | 0.48 (2.58) | 0.74 (7.02) |
| $(\hat{x} - \hat{x}^e)_{t-2}$ | 0.40 (2.17) | 0.38 (3.11) | 0.47 (6.71) |
| $(\hat{x} - \hat{x}^e)_{t-3}$ | 0.21 (0.95) | 0.34 (2.17) | 0.34 (3.38) |
| $(\hat{x} - \hat{x}^e)_{t-4}$ | 0.99 (4.43) | 0.86 (5.41) | 1.12 (11.09) |
| $(\hat{x} - \hat{x}^e)_{t-5}$ | 1.15 (4.06) | 0.82 (3.43) | 1.15 (8.72) |
| R^2_{adj} | 0.7426 | 0.8460 | 0.9375 |
| F | 6.88 | 10.99 | 28.12 |
| D.W. | 0.84 | 0.84 | 1.90 |

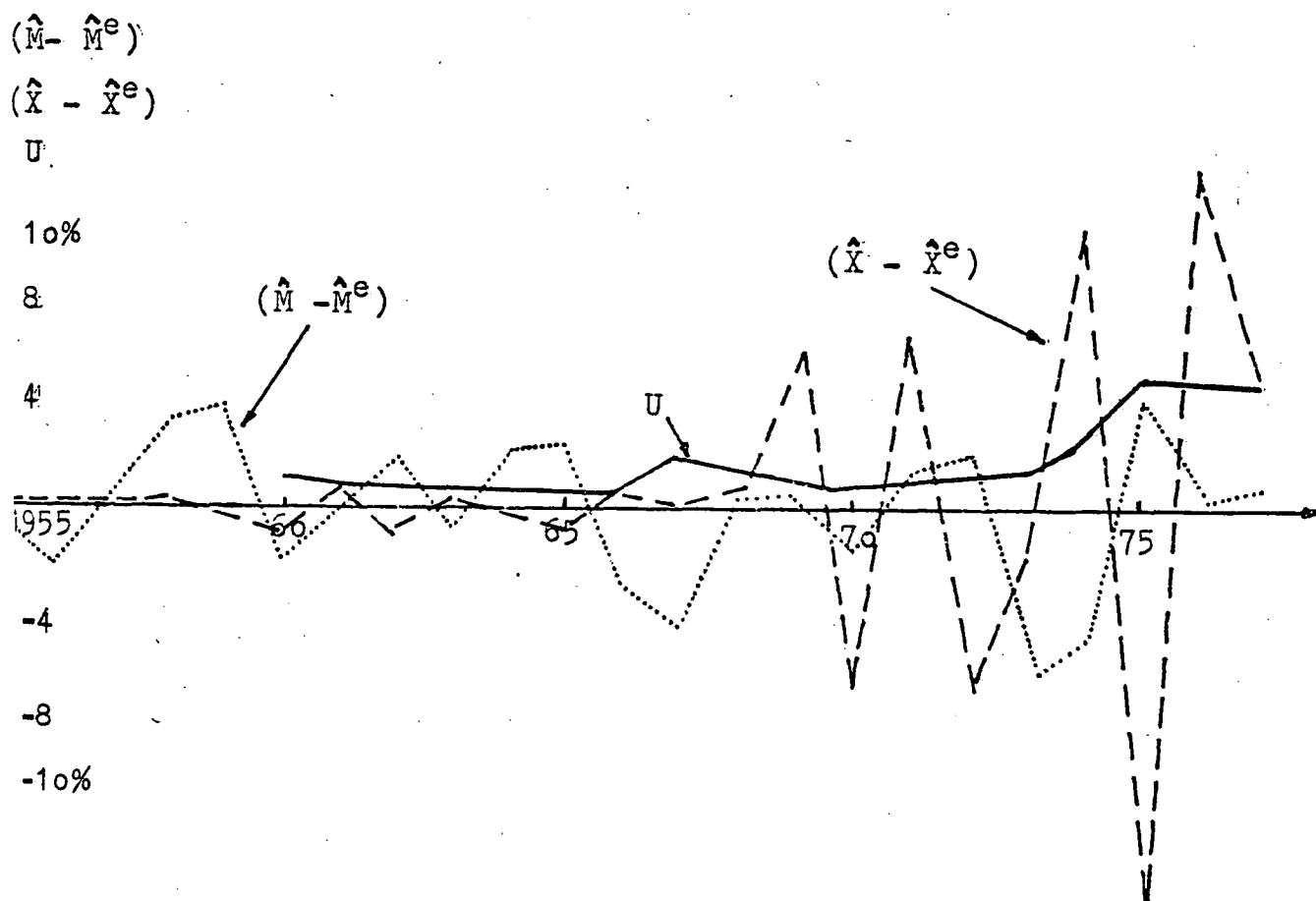
One interesting feature of this test concerns the $(\tilde{M} - \hat{M}^e)$ -parameters. Barro's studies for the U.S. (see Barro (1977) and (1978)) suggested that a 1% unanticipated money growth for three succeeding years leads to a reduction in the unemployment rate of 1 percentage point. Our results imply an unemployment rate reduction of only half a percentage point. Together with the results for real GNP (page 49) there is a 1 to 4 relationship between employment and output which is very close to the Okun-relationship and the one found by Barro (1978, 555) which is on a 1 to 3 basis.

Again the impact of $(\hat{x} - \hat{x}^e)_{t-1}$ is of greater importance, which demonstrates that direct investments have strong real effects for the BRD economy.

From the constant term of equation (37) we can deduce for the whole period 1960-77 a natural rate of unemployment u^* of 1.88%. Certainly this u^* -value is too high for the first half of the test period and too low for the second. This is demonstrated by Fig. 3, which shows the time-paths of the unemployment rate u , $(\hat{M} - \hat{M}^e)$ and $(\hat{x} - \hat{x}^e)$.

To take account of the behavior of $(1-u^*)$ we first approximate $(1-u^*)$ by a linear trend (see equation (38) in Table 14). In a last testing equation a dummy-variable D_{60-68}^{60-68} is used to take account of the break in u^* as shown in Fig. 3. Because the last regression fits the empirical data much better than (38), we focus

Fig. 3 : Unemployment Rate (u), Unanticipated Money Growth ($\hat{M} - \hat{M}^e$) and Unexpected Exchange Rate Growth ($\hat{X} - \hat{X}^e$) in Germany



our interpretation on (39). Compared with (37) ($u^* =$ constant) we get an improvement in the R^2 -value of almost 20% points. The high t-ratio of the dummy-variable D_{60-68}^{69-70} suggests that there is indeed a break in the natural rate of unemployment. We obtain for u^* a value of 1.2% in the first subperiod 1960-68. During the remaining time 1969-77 u^* more than doubles and reaches 2.6%.¹²⁾

There are many possible explanations for this phenomenon in Germany: increasing transfer payments to the unemployed, immobilities within the labour force etc. We would like to stress one point, which is a consequence of the analysis and, in our opinion, sheds some new light on some very important but never mentioned determinants of the natural rate in an open economy: if an economy faces more fluctuations in the behavior of actual and expected exchange rates and the money supply, higher costs of information and lower knowledge about existing alternatives arise in the aggregate labour and goods markets. This situation of greater confusion implies greater search for new jobs by the employees and greater "real surprises" for entrepreneurs in the realization of their production plans. As a consequence larger fluctuations in real output and employment (natural and actual) occur.

In the special case of Germany we observe a tremendous increase in the variation of $(\hat{x} - \hat{x}^e)$ since 1968, as is demonstrated in Fig. 3. This development was initiated by a large speculative inflow of international short-term capital and was forced by the inconsistent policies of German monetary authorities (central bank and government), who switched in the years from 1968 to 1973 and also recently between fixed, dirty floating and flexible exchange rate systems. Given that the German export sector produces about 30% of all German production, it should not be surprising that the unanticipated variation in $(\hat{x} - \hat{x}^e)$ had such great real effects.

5. Concluding Remarks

Our study analyses in a theoretical part the effects of unanticipated monetary variables on real output, inflation rate, interest rate, and other aggregate economic variables for different exchange rate systems. The unanticipated monetary variables are: unanticipated money growth and unanticipated exchange rate movements. It is shown that in a flexible exchange rate system real effects occur, if the growth rate of the money supply differs from the expected inflation rate and if the expected exchange rate is different from the expected inflation rates home and abroad. In fixed rate and dirty floating systems, real output, inflation and employment are also influenced by the difference between the actual and the expected exchange rate movement.

We tested the hypothesis partly for real output and the employment rate for West Germany 1960 to 1977 with annual data.

The empirical tests lead to some important conclusions:

- (1) Unanticipated money supply growth and unexpected exchange rate movements provide good explanations for the behavior of real output and employment in Germany.
- (2) The economic experience in Germany since 1960 is not adequately described by a flexible exchange rate model. A significant influence of purchasing power parity theoretic effects is not confirmed empirically. This may be due to the relatively short time period studied.

- (3) The effect of unanticipated exchange rate growth on real output and employment is both stronger and longer compared with the influence of unanticipated monetary growth.
- (4) Since 1968 Germany has been confronted with large variations in the movements of the unexpected exchange rate. This imposes higher information costs and a greater degree of uncertainty on the economy, especially in the export sector and in the process of anticipation of actions. As a consequence a greater natural rate of unemployment is observed.

The policy implications of our analysis can be summarized as follows: monetary policy must avoid substantial differences ($\hat{M} - \hat{M}^e$) and particularly ($\hat{x} - \hat{x}^e$). This implies a more steady behavior of the money supply and flexible exchange rates, because the crucial difference ($\hat{x} - \hat{x}^e$) only has real effects in a fixed or dirty floating system.

Footnotes

- 1) Concerning the real impact of monetary policy these results are far more rigorous than those obtained by Friedman (1968, 1977) and Phelps (1967, 1972), who only stress the ineffectiveness of monetary policy in the long run.
- 2) In a recent study Shreffrin (1979) points out that unanticipated monetary and fiscal policy measures have real effects but do not affect inflationary expectations. In his model real effects occur because firms cannot distinguish between inventory fluctuations arising from aggregate demand shocks and those attributable to changes in the firms' market share.
- 3) In a similar context this point is stressed by Parkin (1976, p.253).
- 4) Though M^d in our later empirical analysis is narrowly defined as the demand for M_1 , it is also possible to widen this definition. In a similar context, Lindbeck (1976, p.136) includes all financial assets.
- 5) To define equation (7) in real terms is difficult because of the need to use different deflators. This can easily be seen if we write the balance of payments identity in the form:

$$\Delta FA = P.EX(...) - P_A.x.IM(...) + P_A.x.C^{IM}(...)$$

$$- P.C^{EX}(...),$$
where EX = exports, IM = imports, C^{IM} = capital imports, C^{EX} = capital exports (all in real terms).

- 6) Such a policy does not imply that monetary authorities can control x and ΔFA simultaneously. But because the central bank determines the quantitative impact of a given disequilibrium in the balance of payments on x and ΔFA , both variables have to be treated as exogenous.
- 7) This can be seen in the "Gesetz über die Deutsche Bundesbank" from 1957 and in the so called "stabilization and growth law" ("Gesetz zur Förderung der Stabilität und des Wachstums der Wirtschaft") from 1967.
- 8) Definitions and problems of the term "bank liquidity" in Germany are extensively described in Neumann (1972) and Willms (1972).
- 9) Our empirical data for \hat{M} (defined as currency + demand deposits) differ from the official statistics of the German central bank (e.g. Deutsche Bundesbank (1976)). The \hat{M} -values here are computed on the basis of monthly values as yearly averages, whereas the DBB figures for \hat{M} refer to end of year data.
- 10) The same is true for longer lags of $(\hat{x} - \hat{x}^e)$. If we lag, for example, $(\hat{x} - \hat{x}^e)$ for six periods, the β_1^j parameter for $(\hat{x} - \hat{x}^e)_{t-6}$ is insignificant and the other statistics are not improved.
- 11) See also Emminger (1976, p.536) and particularly Junz and Rhomberg (1973, p. 412 - 418), who obtain similar long lags for the export sector.
- 12) This u^* value is obtained by adding the two dummies (98.76 - 1.39) and subtracting this difference from one.

Appendix 1: Additional Empirical Tests of the Purchasing
Power Parity Effect in Different Exchange
Rate Systems

(In contrast to the variables used in the text, we approximate \hat{P}^e by \hat{M}^e in the purchasing power parity formulation and \hat{P}_A by \hat{P}_{OECD} and \hat{M}_{US} , respectively).

Flexible Exchange Rate System

| Dependent Variable | y_t | y_t | $(1-u)_t$ | $(1-u)_t$ |
|--|-------------------|-------------------|--------------------|--------------------|
| Constant Term | 517.72 (28.19) | 504.77 (21.84) | 100.98 (117.83) | 101.53 (100.68) |
| Trend Variable | 18.23 (21.58) | 19.87 (26.20) | | |
| Dummy Variable $D_{60-68/69-77}$ | | | -1.73 (1.95) | -1.16 (2.15) |
| $(\hat{M} - \hat{M}^e)_t$ | 1.17 (0.74) | 1.83 (1.30) | 0.16 (1.37) | 0.13 (1.48) |
| $(\hat{M} - \hat{M}^e)_{t-1}$ | 2.20 (1.71) | 3.02 (2.83) | 0.19 (2.00) | 0.20 (2.96) |
| $(\hat{M} - \hat{M}^e)_{t-2}$ | 1.03 (0.44) | 2.58 (1.50) | 0.14 (0.78) | 0.17 (1.53) |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_t$ | -1.20 (1.64) | | -0.05 (0.76) | |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_{t-1}$ | -0.67 (1.02) | | -0.04 (0.87) | |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_{t-2}$ | -0.08 (0.11) | | 0.0 (0.0) | |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_{t-3}$ | 0.39 (0.40) | | 0.9 (1.18) | |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_{t-4}$ | 1.40 (1.56) | | 0.16 (2.57) | |
| $(\hat{x}^e - \hat{M}^e + \hat{M}_{US})_{t-5}$ | 1.34 (1.12) | | 0.08 (0.78) | |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_t$ | | -0.44 (0.81) | | -0.0 (0.10) |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_{t-1}$ | | -0.81 (1.38) | | -0.02 (0.48) |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_{t-2}$ | | -1.03 (1.92) | | -0.04 (1.08) |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_{t-3}$ | | 0.57 (0.54) | | 0.05 (0.60) |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_{t-4}$ | | 2.35 (2.89) | | 0.22 (4.56) |
| $(\hat{x}^e - \hat{M}^e + \hat{P}_{OECD})_{t-5}$ | | 0.53 (0.53) | | 0.14 (1.16) |
| R^2_{adj} | 0.988 | 0.992 | 0.640 | 0.796 |
| F | 150.1 | 220.2 | 4.31 | 8.11 |
| D.W. | 1.81 | 2.03 | 1.38 | 1.43 |

Fixed Exchange Rate and Dirty Floating System

| Dependent Variable | y_t | y_t | $(1-u)_t$ | $(1-u)_t$ |
|--|-------------------|-------------------|-------------------|-------------------|
| Constant Term | 304.35 (32.98) | 279.61 (26.98) | 99.37 (112.04) | 97.55 (105.27) |
| Trend Variable | 17.97 (23.91) | 19.29 (27.31) | | |
| Dummy Variable $D_{60-68/69-77}$ | | | -1.32 (1.59) | -1.44 (1.77) |
| $(\hat{M}-\hat{M}^e)_t$ | 0.96 (0.64) | 0.94 (0.63) | 0.09 (0.54) | 0.05 (0.28) |
| $(\hat{M}-\hat{M}^e)_{t-1}$ | 1.23 (0.75) | 2.07 (1.54) | 0.09 (0.50) | 0.11 (0.80) |
| $(\hat{M}-\hat{M}^e)_{t-2}$ | -2.10 (1.20) | 0.44 (0.26) | -0.16 (0.72) | -0.04 (0.21) |
| $(\hat{x}-\hat{M}^e+\hat{M}_{US})_t$ | -2.31 (1.81) | | -0.13 (0.76) | |
| $(\hat{x}-\hat{M}^e+\hat{M}_{US})_{t-1}$ | -1.56 (0.95) | | -0.13 (0.72) | |
| $(\hat{x}-\hat{M}^e+\hat{M}_{US})_{t-2}$ | 2.71 (2.78) | | 0.27 (2.45) | |
| $(\hat{x}-\hat{M}^e+\hat{P}_{OECD})_t$ | | -0.32 (0.34) | | -0.04 (0.35) |
| $(\hat{x}-\hat{M}^e+\hat{P}_{OECD})_{t-1}$ | | -3.32 (2.82) | | -0.24 (2.10) |
| $(\hat{x}-\hat{M}^e+\hat{P}_{OECD})_{t-2}$ | | 0.68 (0.73) | | 0.06 (0.62) |
| $(\hat{x}-\hat{x}^e)_t$ | 0.22 (0.16) | 1.48 (1.04) | -0.02 (0.08) | 0.15 (0.92) |
| $(\hat{x}-\hat{x}^e)_{t-1}$ | -0.69 (0.20) | 4.44 (1.58) | 0.01 (0.02) | 0.44 (1.46) |
| $(\hat{x}-\hat{x}^e)_{t-2}$ | -1.99 (0.72) | 3.87 (1.51) | -0.10 (0.33) | 0.36 (1.41) |
| R^2_{adj} | 0.988 | 0.988 | 0.206 | 0.319 |
| F | 145.3 | 155.1 | 1.57 | 1.94 |
| D.W. | 1.40 | 1.64 | 1.53 | 1.28 |

Appendix 2: List of Data Used in Empirical Tests

y^p : potential output in Germany, computed as a linear trend from 1960 - 1977

y_t : real GNP in Germany (at 1962 prices)
sources: Statistisches Bundesamt, Fachserie N, Reihe 3;
Sachverständigengutachten, different volumes;
1975 - 1977: our computation from nominal data

\hat{P} : domestic (German) consumer price index
sources: Monatsberichte der Deutschen Bundesbank, different volumes

\hat{P}_A : = P_{OECD} : average inflation rate of 10 OECD-countries,
sources: OECD (ed.), Main Economic Indicators, different volumes

M : M_1 = CP + D (currency + demand deposits), yearly averages of end of month stocks in Germany
sources : Federal Reserve Bank of St. Louis (ed.), Rates of Change in Economic Data for ten Industrial Countries;
Monatsberichte der Deutschen Bundesbank, different volumes, growth rates: our computations

M_{US} : M_1 , yearly averages of end of month stocks in U.S.
sources: Federal Reserve Bank of St. Louis (ed.), Rates of Change in Economic Data for ten Industrial Countries

- x : spot rate (Kassakurs \$/DM), yearly averages
sources: Statistische Beihefte zu den Monatsberichten
der Deutschen Bundesbank, Reihe 5;
International Financial Statistics,
different volumes
- x^e : forward rate, three months forward rate,
(Devisenterminkurs \$/DM), end of year data
sources: Statistische Beihefte zu den Monatsberichten
der Deutschen Bundesbank, Reihe 5;
International Financial Statistics,
different volumes
- u : unemployment rate in % of all employees (unselb-
ständige Erwerbspersonen) in Germany, yearly
averages
sources: Monatsberichte der Deutschen Bundesbank,
different volumes
- FA : net foreign position of the Deutsche Bundesbank,
yearly averages
sources: Monatsberichte der Deutschen Bundesbank,
different volumes
- i_3^s : short term interest rate, three month money market
interest rate, % p.a.
sources: Monatsberichte der Deutschen Bundesbank,
different volumes

| Year | y_t GNP at 1962 prices in bill. DM in Germany | \hat{P} Inflation Rate in Germany % p.a. | \hat{P}_A Inflation Rate in OECD countr. % p.a. | \hat{M} Growth Rate of German Money Stock | \hat{M}_{US} Growth Rate of US Money Stock, %p.a. | u Unemployment Rate in Germany |
|------|--|---|--|--|--|---|
| 1955 | 224.9 | 1.6 | 1.2 | 11.2 | 3.1 | 5.2 |
| 1956 | 241.3 | 2.5 | 2.4 | 9.0 | 1.2 | 4.2 |
| 1957 | 255.0 | 2.2 | 3.6 | 10.3 | 0.5 | 3.5 |
| 1958 | 264.5 | 2.0 | 3.4 | 12.8 | 1.2 | 3.6 |
| 1959 | 283.8 | 1.1 | 2.2 | 13.8 | 3.7 | 2.5 |
| 1960 | 328.4 | 1.4 | 1.8 | 8.3 | -0.1 | 1.3 |
| 1961 | 346.2 | 2.3 | 1.6 | 9.4 | 2.1 | 0.9 |
| 1962 | 360.1 | 2.9 | 2.2 | 10.9 | 2.2 | 0.7 |
| 1963 | 372.5 | 3.0 | 2.4 | 7.4 | 2.9 | 0.9 |
| 1964 | 397.3 | 2.4 | 2.3 | 8.3 | 3.9 | 0.8 |
| 1965 | 419.5 | 3.4 | 2.9 | 9.0 | 4.2 | 0.7 |
| 1966 | 431.7 | 3.5 | 3.4 | 4.2 | 4.4 | 0.7 |
| 1967 | 430.8 | 1.5 | 3.0 | 3.5 | 3.9 | 2.1 |
| 1968 | 462.3 | 1.3 | 4.0 | 7.5 | 6.8 | 1.5 |
| 1969 | 500.4 | 2.0 | 4.8 | 8.1 | 6.1 | 0.9 |
| 1970 | 529.4 | 3.2 | 5.6 | 6.5 | 4.4 | 0.7 |
| 1971 | 545.2 | 5.1 | 5.3 | 11.9 | 6.7 | 0.9 |
| 1972 | 563.5 | 5.3 | 4.9 | 13.6 | 6.3 | 1.1 |
| 1973 | 592.4 | 6.8 | 8.0 | 5.8 | 7.1 | 1.3 |
| 1974 | 595.0 | 6.8 | 13.6 | 6.0 | 5.5 | 2.6 |
| 1975 | 576.7 | 6.6 | 12.2 | 13.8 | 4.2 | 4.7 |
| 1976 | 608.7 | 4.5 | 8.6 | 10.3 | 6.0 | 4.6 |
| 1977 | 624.6 | 3.9 | 8.9 | 8.3 | 8.3 | 4.5 |

| Year | x Spot Rate DM/\$ | x^e Forward Rate DM/\$ | $(\hat{x}-\hat{x}^e)$ Unanticipated Exchange Rate Growth, % p.a. | $(\hat{M}-\hat{M}^e)$ Unanticipated Money Growth % p.a. | FA Net Foreign Position of the DBB in Billion DM | i_3^s Short Term Interest Rate % p.a. |
|------|-------------------------|--------------------------------|---|--|--|--|
| 1955 | 4.2107 | | 0.0 | -0.4845 | 11.065 | 4.20 |
| 1956 | 4.2030 | | 0.0 | -1.8003 | 14.784 | 6.15 |
| 1957 | 4.2012 | | 0.0 | 0.3678 | 20.232 | 4.95 |
| 1958 | 4.1919 | 4.177 | 0.35 | 2.7773 | 24.177 | 3.60 |
| 1959 | 4.1791 | 4.171 | -0.16 | 3.7437 | 23.270 | 3.22 |
| 1960 | 4.1704 | 4.165 | -0.06 | -1.6002 | 28.595 | 5.10 |
| 1961 | 4.0221 | 3.986 | 0.74 | -0.1565 | 31.339 | 3.59 |
| 1962 | 3.9978 | 3.994 | -0.80 | 1.8929 | 29.966 | 3.42 |
| 1963 | 3.9864 | 3.972 | 0.27 | -0.7145 | 31.712 | 3.41 |
| 1964 | 3.9748 | 3.970 | -0.24 | 1.9875 | 33.454 | 4.09 |
| 1965 | 3.9943 | 4.003 | -0.34 | 2.4771 | 32.604 | 5.14 |
| 1966 | 3.9982 | 3.978 | 0.71 | -2.7978 | 32.455 | 6.63 |
| 1967 | 3.9866 | 3.964 | 0.06 | -3.9804 | 34.044 | 4.27 |
| 1968 | 3.9923 | 3.9585 | 0.27 | 0.4621 | 37.759 | 3.79 |
| 1969 | 3.9244 | 3.6799 | 5.33 | 0.7804 | 38.959 | 5.79 |
| 1970 | 3.6463 | 3.6460 | -6.16 | -1.6570 | 38.852 | 9.42 |
| 1971 | 3.4795 | 3.2525 | 6.22 | 1.6025 | 60.826 | 7.15 |
| 1972 | 3.1889 | 3.1863 | -6.32 | 2.1148 | 71.113 | 5.61 |
| 1973 | 2.6590 | 2.7100 | -1.67 | -5.2471 | 89.090 | 12.14 |
| 1974 | 2.5897 | 2.3965 | 8.96 | -4.2381 | 88.460 | 9.90 |
| 1975 | 2.4631 | 2.6083 | -13.71 | 3.7402 | 81.779 | 4.96 |
| 1976 | 2.5173 | 2.3603 | 11.70 | 0.3645 | 91.021 | 4.25 |
| 1977 | 2.3217 | 2.0800 | 4.10 | 1.0373 | 86.677 | 4.36 |

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