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Working Paper

International trade in a disequilibrium model

Diskussionsbeiträge - Serie II, No. 124

Provided in Cooperation with:

Department of Economics, University of Konstanz

Suggested Citation: Franz, Wolfgang; Heidbrink, Gustav W.; Scheremet, Wolfgang (1990) : International trade in a disequilibrium model, Diskussionsbeiträge - Serie II, No. 124, Universität Konstanz, Sonderforschungsbereich 178 - Internationalisierung der Wirtschaft, Konstanz

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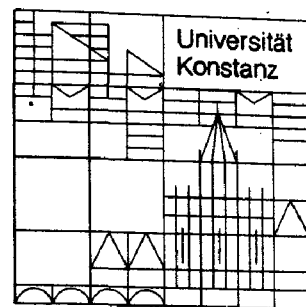
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Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“

Diskussionsbeiträge



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**International Trade
in a Disequilibrium Model**

INTERNATIONAL TRADE IN A DISEQUILIBRIUM MODEL*

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Serie II - Nr. 124

November 1990

* *We are grateful to W. Smolny (University of Konstanz), W. Gaab (University of Essen), J.P. Lambert (CORE and Facultés Universitaires Saint-Louis/Brussels), K. Sauernheimer (University of Essen) and J. Wolters (Free University of Berlin) for helpful comments.*

Abstract

The present paper is confined to a macroeconomic disequilibrium model for the Federal Republic of Germany. The model consists of three main building blocks: goods and labour markets and a monetary sector. Allowing for spillovers between goods and labour markets our main concern is to explain the fluctuations of aggregate output and employment. Their flexibility depends on the time span under consideration. Output and employment decisions are modelled by a three step structure. The econometric set-up emphasizes the importance of international trade flows within a disequilibrium framework. In these models international trade is influenced by supply and demand constraints on national goods markets. More specially, imports lower national supply constraints whereas exports can be hindered by excess demand on domestic markets. These hypotheses are tested for bilateral trade flows of the FRG with five EC-countries and the USA. Our estimation results show a significant influence on imports while there is little if any evidence that exports are influenced by excess demand on home markets. The dynamic performance of the model is discussed in the last part of the paper.

I Introduction and Scope of the Study

The past decade has witnessed an emerging literature on disequilibrium models. Some of them are now already topics in macroeconomic textbooks such as Branson (1989) who concludes that a more general disequilibrium model is needed to analyze open economies (p. 466). On a theoretical basis Franke (1989) provides a useful survey of different approaches to integrate foreign trade into New Keynesian models. Moreover, Drèze and Bean (1990) review the attempts of a group of (mostly European) researchers to implement econometric disequilibrium models. Most of these models surveyed, however, contain only a fragmentary foreign sector.

The aim of this paper is to take a first step in building a macroeconometric disequilibrium model for the Federal Republic of Germany as an open economy. More specifically, we want to investigate the importance of rationing schemes in the presence of international trade flows. This possibility of rationing is introduced in the following way. An excess demand for domestic goods by domestic firms or private households may induce additional imports in order to attempt to bypass this constraint. On the other hand, an excess demand on the world market may restrain German imports. The opposite theoretical argument holds for German exports: Domestic constraints may hinder foreign goods demand, i.e., foreign import is rationed on the domestic market, while German exporting firms may face demand constraints on the world market. Finally, supply constraints in foreign markets may induce additional German exports. An interesting question in this context is the empirical relevance of hysteresis in international trade. The argument stressed by Baldwin (1990), for example, is that firms will not give up foreign markets even if the favourable conditions which have led to the entry into the foreign markets (such as advantageous exchange rates) disappear.¹ The basic point is that foreign firms can enter a domestic market only by incurring once-for-all sunk costs. A temporary and sufficient rise in the exchange rate will cause permanent entries by foreign firms. Due to these sunk costs firms will find it profitable to stay in the domestic market even when the exchange rate returns to its former level. The reverse argument holds for domestic firms entering foreign markets.

As has been mentioned the present study attempts to test the empirical evidence of these possible rationing schemes within the framework of a macroeconometric disequilibrium model.² In the past decade much work has been done on the specification and estimation of multimarket macroeconomic disequilibrium models such as Artus, Laroque and Michel (1984), Muellbauer and Portes (1978), Malinvaud (1980), and, more recently, Stalder (1989) and Laroque (1989). The latter study gives comparative estimates of a macroeconomic disequilibrium model for several countries based on pseudo maximum likelihood methods. For the Federal Republic

¹See Franz (1990) for an overview of the hysteresis phenomenon.

²See Franz and König (1990) for the following short overview.

of Germany, Laroque's model winds up with the conclusion that since 1981 unemployment is virtually Keynesian in nature whereas the seventies can be characterized by a mixture of classical and Keynesian regimes. While our results are in line with Laroque's estimates for the seventies, they are at variance for the eighties. For this period our model finds a declining importance of demand constraints in due course of restrictive monetary and fiscal policies at the beginnings of the eighties which led to an investment squeeze. Hence, capacity constraints play an important role in the second half of the eighties.

Since the basic philosophy of our model is outlined in the next section only a few words are in order. The model presented in this paper is the outcome of the efforts of a larger international project surveyed by Drèze and Bean (1990) and is based on studies by Entorf, Franz, König and Smolny (1989) and Franz and König (1990). Although its conceptual framework follows the lines suggested by Sneessens (1987) and Sneessens and Drèze (1986), a large variety of modifications and extensions are made. A specific feature of all these models is the aggregation procedure put forward recently by Lambert (1988). Basically, the concept follows the "smoothing by aggregation" method and rests on the hypothesis that the well-known minimum condition holds only for micro markets rather than for the aggregate economy as in earlier studies. Assuming that the statistical distribution of demand and supply on the micro markets can be described by a joint log-normal distribution, Lambert (1988) is able to show that aggregate transactions can be approximated by a CES-type function of the aggregate concepts of demand and supply. This procedure implies a smooth change of regimes shares in contrast to the sudden (and unrealistic) switches implied by the earlier studies. Moreover, this method is capable of taking into account the widely observable fact that both unemployment and vacancies exist at the same time.

In what follows we first give a brief impression of the basic philosophy of the model. Then the theoretical set-up and the econometric results are described in more detail with special reference to international linkages. Finally, the performance of the model is discussed. The conclusion summarizes our findings and caveats.

II Basic Structure of the Model

Since the basic philosophy of the model has been surveyed elsewhere³ we can be very brief and concentrate on our own modifications and extensions.

To begin with output and employment decisions, their flexibility depends on the time span under consideration.⁴

³See Franz and König (1990) and Drèze and Bean (1990), for example.

⁴The following considerations are partly based on Smolny (1990) where a more detailed analysis of various aspects is presented.

- (i) In the short-run the firm's supply of output is fixed and the transacted quantities on the market (YT) are the minimum of the goods demanded (YD) and goods supplied (YS), i.e.,

$$YT = \min(YD, YS). \quad (1)$$

- (ii) In the medium-run employment can be subject to variations, whereas the capital stock is still a fixed factor of production. Employment (LT) is then the minimum of labour demanded (LD) and labour supplied (LS), i.e.,

$$LT = \min(LD, LS). \quad (2)$$

The demand for labour is either determined (as L^*) by goods demand (YD) or (as L_{YC}) by the optimal utilization of existing capacities (YC). Consider L_{YC} first and note that, by definition,

$$L_{YC} \equiv \frac{YC}{(Y/L)^*} \equiv K \cdot \left(\frac{Y}{K}\right)^* / \left(\frac{Y}{L}\right)^*, \quad (3)$$

where the terms in brackets denote optimal capital and labour productivity, respectively. They can be derived from the first order conditions of a cost minimizing firm given a CES-technology and depend on factor price ratios and efficiency terms reflecting labour and capital saving technical progress, respectively. The determination of L^* is best understood by recognizing that in the optimum marginal costs of labour (i.e., the wage rate W) should equal marginal returns from labour (P is the price for goods):

$$W = P \cdot \text{prob}[YD > Y_{LT}] \cdot \left(\frac{Y}{L}\right)^* \quad (4)$$

The r.h.s. term of eq. (4) reflects the marginal returns from labour. The second expression stands for the probability that expected goods demand exceeds those quantities (Y_{LT}) which can be produced with existing labour (LT). As is shown in the appendix, from eq. (4) one can develop the following equation for labour demand by making use of a log-normal distribution of excess demand on micro markets and a logistic approximation of the cumulative distribution function:

$$L^* = E(YD) \cdot \left(\frac{L}{Y}\right)^* \cdot \left[\exp(-0.5 \cdot \sigma_{yd}^2) \cdot \left(\frac{1 - sl}{sl}\right)^\alpha \right] \quad (5)$$

where E is the expectations operator, σ_{yd}^2 is the logarithmic variance of goods demand, and

$$sl = \frac{W}{P} \cdot \left(\frac{L}{Y}\right)^*, \quad \alpha = \frac{\sigma_{yd} \cdot \sqrt{3}}{\pi}.$$

- (iii) In the long-run firms can adjust potential output (YC) by changing the capital stock (K) and/or the production technology. More specifically, YC is determined by the condition that the expected marginal return of capital should equal capital costs. The first order condition for an optimal capital stock is given by equating the marginal revenue from capital minus the additional labour costs for a marginal investment with marginal capital costs (UC):

$$P \cdot \text{prob}(Y^A > YC) \cdot \left(\frac{Y}{K}\right)^* - W \cdot \text{prob}(Y^A > YC) \cdot \left(\frac{L}{Y}\right)^* \cdot \left(\frac{Y}{K}\right)^* = UC \quad (6)$$

or:

$$\left[P - W \cdot \left(\frac{L}{Y}\right)^*\right] \cdot \left(\frac{Y}{K}\right)^* \cdot \text{prob}(Y^A > YC) = UC \quad (7)$$

where Y^A is a symbol denoting the minimum of Y_{LS} , Y_{L^*} and YD :

$$Y^A \equiv \min \{Y_{LS}, Y_{L^*}, YD\}. \quad (8)$$

Y_{LS} is output which can be produced with available labour supply and Y_{L^*} is output produced by the optimal labour demand L^* . YD , Y_{L^*} , Y_{LS} are the possible constraints that may prevent the firm from full utilization of capacities.

$$Y_{LS} = LS \cdot \left(\frac{Y}{L}\right)^*, \quad (9)$$

$$Y_{L^*} = L^* \cdot \left(\frac{Y}{L}\right)^*. \quad (10)$$

Solving for ($\text{prob}(Y^A > YC)$) yields the expression:

$$\text{prob}(Y^A > YC) = \frac{sk}{1 - sl} \quad (11)$$

with

$$sk = \frac{UC}{P} \cdot \left(\frac{K}{Y}\right)^*.$$

From this the following equation for YC can be developed by making use of the same methods as in step (ii):

$$YC = E(Y^A) \cdot \left[\exp(-0.5 \cdot \sigma_{Y^A}^2) \cdot \left(\frac{1 - sl - sk}{sk} \right)^\alpha \right] \quad (12)$$

Capacities are chosen proportional to the expected minimum of goods demand YD and goods supply Y_{L^*} and Y_{LS} determined by L^* and LS . Further determinants are a measure of profitability and the variance of $\log Y^A$.

Then K is obtained by:

$$K = \left(\frac{K}{Y}\right)^* \cdot YC. \quad (13)$$

We now turn to the aggregation of demand and supply quantities from the micro goods and labour markets to economy wide quantities. Following Lambert (1988) we assume the joint statistical distribution of micro level goods demand and supply to obey a bivariate lognormal distribution. Aggregation over micro markets then yields a tractable functional form for goods transacted YT ("smoothing by aggregation"):

$$YT = \{Y_{LT}^{-\rho_1} + YD^{-\rho_1}\}^{-\frac{1}{\rho_1}} \quad (14)$$

The two variables Y_{LT} and YD in the CES-function have the following interpretation. Y_{LT} is output determined by employment times optimal productivity, i.e. labour productivity at full utilization of labour. As has been mentioned (see the discussion of eq.(3)) the latter is obtained by regressing actual labour productivity, on among others, factor prices and capacity utilization. Using this regression and calculating labour productivity for full utilization gives the aforementioned optimal labour productivity. In our model consumers and investors can bypass rationing on domestic markets by additional imports. This is the more likely the higher the capital utilization. If so, parts of imports are due to domestic rationing barriers and "structural imports" denote imports in the absence of domestic rationing. They are obtained by using the estimated import demand function (which includes capacity utilization as one of the explanatory variables). Hypothetical imports are then calculated for the historical minimum of capacity utilization thereby assuming that no rationing occurred at that date. From this it follows that structural imports usually fall short of actual imports. The opposite holds for structural exports which exceed actual exports. Domestic constraints will hinder the more likely foreign demand the higher the domestic capacity utilization. Only a situation with no rationing on the domestic market actual exports equal the structural exports.

A mismatch parameter ρ_1 enters the CES-function. It measures the mismatch of supply and demand on the goods markets. For $\rho_1 \rightarrow \infty$ equation (14) tends to the usual minimum-condition, i.e., now not only each micro market but also the aggregate economy is subject to only one of the constraints.

Similar arguments can be applied to the labour market. Transacted labour LT , i.e., employment, is determined either by labour supply LS or by labour demand LD . The latter is split into labour demand based on expected goods demand (L^*) and labour demand brought about by productive capacities L_{YC} . By the same way of reasoning we obtain:

$$LT = \{LS^{-\rho_2} + (L^*)^{-\rho_2} + (L_{YC})^{-\rho_2}\}^{-\frac{1}{\rho_2}}. \quad (15)$$

Eq. (15) can be transformed into elasticities of LT with respect to LS , L^* , and L_{YC} . Moreover, these elasticities can be shown to represent share of firms ("regimes") being

constrained either by labour supply, goods demand, or capacities:

$$\left. \begin{aligned} \epsilon_{LT,LS} &= \{LT/LS\}^{\rho_2} \\ \epsilon_{LT,LYD} &= \{LT/(L^*)\}^{\rho_2} \\ \epsilon_{LT,LYC} &= \{LT/LYC\}^{\rho_2} \end{aligned} \right\} \quad (16)$$

Similar elasticities can be derived from eq. (14) for the goods market. The elasticities of YT with respect to Y_{LT} and YD represent the shares of firms being constrained either by supply or by demand on the goods markets.

$$\left. \begin{aligned} \epsilon_{YT,Y_{LT}} &= \{YT/Y_{LT}\}^{\rho_1} \\ \epsilon_{YT,YD} &= \{YT/YD\}^{\rho_1} \end{aligned} \right\} \quad (17)$$

These regimes highlight the philosophy of the approach. While the micro markets are governed by the exact minimum-conditions, there is a gradual change of regimes on the aggregate level. As it is well known, the minimum-condition follows from two basic propositions of disequilibrium models, namely voluntary exchange (i.e., no individual can be forced to purchase (sell) more than he demands (supplies)) and market efficiency (i.e., all advantageous transactions are undertaken, hence, only one of each sides of the market can be rationed). However, such a minimum condition on the aggregate level would yield the implausible and, hence, unwarranted result of sudden regime switches: For example, unemployment which yesterday was Keynesian in nature would today be called "Classical", to state it in E. Malinvaud's terms. Moreover, such an approach fails to take into account the coexistence of unemployment and vacancies. The smoothing by aggregation circumvents these shortcomings.

III Behavioural Equations and Estimations

In what follows we describe shortly our behavioural equations and our estimates. We use quarterly data and, with a few exceptions, estimates are based on the period from 1960 to 1988. All regressions include seasonal dummies which are suppressed here. Small case letters denote logs.

III.1 Investment

To allow for an endogenous capital stock net investment has to be explained.⁵ Based on the microeconomic foundations concerning optimal capital stock decisions (see

⁵Our model ignores inventories. We only estimate net investments.

eq. (12) in section II) investment is determined by expected demand for output $E(Y^A)$ and the share of labour and the share of capital, respectively. The growth rate of the capital stock Δk is then determined by:

$$\Delta k = f_{\Delta k} \left(E(Y^A), \frac{1-s_l-s_k}{sk} \right) \quad (18)$$

Both partial derivatives are positive. The expected demand for output can be approximated by using a CES function:

$$E(Y^A) = \{E(Y_{LS})^{-\rho} + E(Y_{L\bullet})^{-\rho} + E(YD)^{-\rho}\}^{-\frac{1}{\rho}}. \quad (19)$$

We tried to estimate this equation but the estimates did not converge. Therefore we calculate the expected demand for output by the following equation:

$$E(Y^A) = \{Y_{LS}^{-\rho_2} + [(1 + \alpha_1) \cdot YD]^{-\rho_2} + [(1 + \alpha_2) \cdot YD]^{-\rho_2}\}^{-\frac{1}{\rho_2}} \quad (20)$$

where ρ_2 is the estimated mismatch parameter of the employment function. The correction term α_1 refers to the determination of $E(Y_{L\bullet})$ in eqs. (19) and (5), respectively. The correction term is due to the lack of significance of the last term in brackets in eq. (5)). Therefore, we replaced this variable by the constant α_1 (the estimated equation is (38)). The second correction term α_2 reflects measurement errors associated with YD . These stem, for example, from an insufficient specification of "structural" imports and exports (the estimated equation is (37)). and α_1 and α_2 are correction factors for measurement errors of YD in the CES functions for output and employment, respectively.⁶

Turning to the second determinant of investment a rising share of capital and a rising share of labour reduce investments due to a profit squeeze. The definition of the share of labour is described in section II. The main determinant of the share of capital is the real interest rate (R_r). Other determinants are the scrapping rate (d), the relative price for investment (PI/P) and the average productivity of the net real capital stock (K_r) at full utilization of capacity.

We estimate the investment equation using an error correction specification including a time trend as a proxy for capital productivity.

$$\begin{aligned} \Delta k = & \text{const.} + 0.011 \Delta y_{-1}^A + 0.001 \Delta Z_{-2} & (21) \\ & (5.35) & (1.77) \\ & + 0.667 \Delta k_{-1} + 0.00005 \text{Trend} \\ & (11.39) & (3.42) \end{aligned}$$

⁶See section III.6.

$$- 0.012 (k_{-3} - 0.590 y_{-4}^A - 0.070 Z_{-4})$$

(-4.29) (6.27) (2.43)

$$\text{with } Z = \frac{1 - sl - sk}{sk}$$

$$\bar{R}^2 = 0.98; \quad \text{SEE} = 0.0006; \quad \text{Q-Stat. (8 lags)} = 46.86$$

Sample 60/1 – 89/2

The regression reveals a very slow adjustment to long run values. A one percent increase of Y^A leads to a 0.6 percent higher capital stock. The long run values for the share of capital and the share of labour indicate a rather strong impact on investment. According to our theory we obtain a small short run reaction of investment to changes in Y^A as well as to changes of the labour and capital shares.

III.2 Consumption

The equation for real consumption is formulated as a fairly standard textbook version. Besides real disposable income (DI), we use a short term interest rate and a labour market indicator as explanatory variables. The latter mirrors the expectations about future income according to the life-cycle hypothesis of consumption. We employ the change of the unemployment rate (ΔUR) as a proxy for this variable. A negative sign indicates that rising unemployment leads to a fall in consumption. The interest rate serves as an indicator for intertemporal consumption/savings decisions.

$$C = f_c(\underset{+}{DI} \underset{-}{\Delta UR}, \underset{-}{R_r}) \quad (22)$$

The dynamic adjustment is reflected by different lags of explanatory variables.⁷ The result shows a consumption function with a long-run marginal propensity to consume of 0.88 in the long run. The real interest rate has a small negative effect on consumption. As expected, a rise in unemployment has a negative impact.

$$\begin{aligned} C = & \text{const.} - 1.528 \Delta UR - 0.170 R_r + 0.482 C_{-1} + 0.327 C_{-4} \\ & \quad (-2.27) \quad \quad (-2.26) \quad \quad (5.56) \quad \quad (4.28) \\ & + 0.468 DI - 0.178 DI_{-1} + 0.047 DI_{-2} + 0.061 DI_{-3} - 0.231 DI_{-4} \\ & \quad (11.20) \quad \quad (-3.29) \quad \quad (1.40) \quad \quad (1.89) \quad \quad (-4.18) \\ \bar{R}^2 = & 0.999 \quad \text{SEE} = 1.509; \quad \text{Q-Stat. (8 lags)} = 6.69 \\ & \text{Sample 60/1 – 89/2} \end{aligned} \quad (23)$$

⁷The regression equation can be rewritten as an error correction model.

III.3 Technology: Labour and Capital Productivity

Assuming ex-ante substitution possibilities between production factors, the technical productivities of labour and capital are determined by the long-run decisions of the firms with respect to the capital stock and the technology. The production function is modelled as a CES-technology with constant returns to scale, including labour-saving (γ_L) and capital-saving (γ_K) technical progress. Maximising profits at given output prices (p) and factor costs (w, uc) we obtain for the technical productivities of labour $(yc - l)^*$ and of capital $(yc - k)^*$, respectively, the following equations:

$$(yc - l)^* = \text{const.} + \sigma(w - p) + (1 - \sigma) \gamma_{L(t)} \quad (24)$$

and

$$(yc - k)^* = \text{const.} + \sigma(uc - p) + (1 - \sigma) \gamma_{K(t)} \quad (25)$$

where σ denotes the elasticity of substitution. The productivities are determined by the factor-product-price ratios and technical progress.

Due to ex-post rigidities of substitution possibilities, actual productivities may deviate from technical values when production factors are not fully utilized. Therefore, actual productivities depend on the technology *and* on the degree of factor utilization.

The labour and capital utilization (Q) rates are measured by business survey data taken by the Ifo-Institut (Munich) which reflect the capacity utilization of the German industry.⁸ Both utilization rates are supposed to exhibit similar movements.⁹ Our estimation of labour productivity improves when we use the capital utilization rate rather than an indicator for labour utilization which is based on overtime work and short-time work. Because employment decisions are taken in the medium run we employ a dynamic specification of the utilization rate of capital. Hourly wages and the price of investment goods serve as factor prices.

Actual labour and capital productivities are jointly estimated by OLS with the adjustment coefficients and the elasticity of substitution being restricted to be equal. Labour- and capital-saving progress is modelled by linear and quadratic time trends. The equations (26) and (28) display our results for labour productivity and capital productivity, respectively. They share common features with the estimates by Entorf, Franz, König, Smolny (1989). As our estimate these authors obtain an elasticity of substitution of $\sigma = 0.3$ based on estimates with annual data. The dynamic structures of both models exhibit a strong impact of one-year-lagged productivities.

The estimates for labour productivities includes actual and lagged capital utilization rates q whereas for capital productivities only the actual rate was significant.

⁸Note that this variable serves as a proxy for a broader definition of aggregate utilization.

⁹Due to longer adjustments of capital stocks we observe a higher variability of the utilization rate of capital.

Labour-saving technical progress decreases slowly during the period under consideration. The corresponding coefficient for capital productivity displays a negative time trend which might result from the energy price shocks, rendering parts of the capital stock obsolete.

$$\begin{aligned}
 yc - l = & \text{const.} + 0.293 \left(\underset{(2.27)}{0.302(w-p)} + \underset{(17.64)}{(1-0.302)} \underset{(-8.67)}{(0.018t - 0.00006t^2)} \right) \quad (26) \\
 & + 0.443(q - 0.513q_{-1}) \\
 & \quad \quad \quad \underset{(6.19)}{} \quad \quad \quad \underset{(5.07)}{} \\
 & + 0.174 \left[(yc - l)_{-1} - 0.443(q_{-1} - 0.513q_{-2}) \right] \\
 & \quad \quad \quad \underset{(2.59)}{} \\
 & + 0.664 \left[(yc - l)_{-4} - 0.443(q_{-4} - 0.513q_{-5}) \right] \\
 & \quad \quad \quad \underset{(14.67)}{} \\
 & - 0.130 \left[(yc - l)_{-5} - 0.443(q_{-5} - 0.513q_{-6}) \right] \\
 & \quad \quad \quad \underset{(-2.04)}{}
 \end{aligned}$$

$$\bar{R}^2 = 0.999; \quad \text{SEE} = 0.0130; \quad \text{Q-Stat. (8 lags)} = 8.40$$

$$\begin{aligned}
 yc - k = & \text{const.} + 0.293 \left[\underset{(2.13)}{0.302(pi-p)} - \underset{(-2.44)}{(1-0.302)} \underset{(-1.26)}{(0.002t + 0.00001t^2)} \right] \quad (27) \\
 & + 0.532q \\
 & \quad \quad \quad \underset{(12.83)}{} \\
 & + 0.174 \left[(yc - k)_{-1} - 0.532q_{-1} \right] \\
 & \quad \quad \quad \underset{(2.44)}{} \\
 & + 0.664 \left[(yc - l)_{-4} - 0.532q_{-4} \right] \\
 & \quad \quad \quad \underset{(13.82)}{} \\
 & - 0.130 \left[(yc - l)_{-5} - 0.532q_{-5} \right] \\
 & \quad \quad \quad \underset{(-1.92)}{}
 \end{aligned}$$

$$\bar{R}^2 = 0.987; \quad \text{SEE} = 0.014; \quad \text{Q-Stat. (8 lags)} = 6.82$$

Sample 61/1 – 89/2

Both regressions highlight the significant influence of capital utilization on measured productivities. Optimal productivities are given by the following equations:

$$(yc - l)^* = (yc - l) - \log(DUL) \quad (28)$$

$$(yc - k)^* = (yc - k) - \log(DUC). \quad (29)$$

The implied values of DUC and DUL are given by:

$$duc = 0.532 \cdot (q - q^{\max}) \quad (30)$$

$$dul = 0.443 \cdot [(q - q^{\max}) - 0.513 \cdot (q - q^{\max})_{-1}]. \quad (31)$$

III.4 Trade

Real exports and imports of the FRG are explained by twelve bilateral trade equations which cover nearly 50 per cent of total nominal exports and imports and, moreover, by two equations for the remaining trade with other countries. We choose the trade with the USA and five EC-countries (United Kingdom, France, Italy, the Netherlands and Belgium) to be explained by separate equations. Foreign income variables and relative price variables are used as explanatory variables.

As has been mentioned, in the context of rationing models excess demand on domestic goods markets is supposed to influence trade. Therefore we include one rationing variable for each country. These variables are proxied by the differences between the rates of capital utilization and their minimum values during the sample period $(q - q^{\min}, (q - q^{\min})^i)$.^{10,11}

Starting with exports the foreign income variable is measured as real foreign GDP and the coefficient associated with total imports of the foreign country i (excluding the imports from Germany) measures general demand for imported goods and reflects the respective share of German imports if all other variables remain unchanged. Inclusion of both variables yield better statistical results despite the fact that both share the same theoretical argument.¹² The relative price variable is defined as the ratio of German export prices (P_x) to the foreign GDP deflator multiplied with the exchange rate. In order to take into account the relative competitiveness of German exports with exports of other countries we construct an index of German export prices relative to export prices of other main industrial

¹⁰It is assumed that there is no rationing (excess demand) if capital utilization is at its minimum.

¹¹We use a simple log-linear structure to model the influence of the degree of capital utilization on trade flows. The chosen linear form might not be quite correct since it is likely that there is a nonlinear relationship between excess demand variable and the capital utilization rate. But in order to calculate the rate of excess demand variable we have to estimate all demand regressions and the output and employment regressions simultaneously. Because of convergency problems when estimating the nonlinear regressions for output and employment we neglect this theoretically more appropriate version and stay with the approximation of the excess demand variable by the degree of capital utilization.

¹²Because of multicollinearity problems it is somewhat difficult to conceive a constant share of German exports to total imports for elasticities of one although we receive elasticity values about one in four regressions. Dropping one of the two demand variables leads to a coefficient of the remaining far above one, indicating increasing international trade.

countries (P_x^w). Both relative prices are expected to be negative while the demand variables should have positive signs.¹³

The rationing variable on the domestic market is expected to be negative in the export equations because excess demand on domestic market could restrain exports. But this variable might be insignificant if export markets dominate home markets. Firms do not give up foreign markets (due to sunk costs, for example) even if domestic market conditions improve (hysteresis in trade).¹⁴ The foreign rationing variable is expected to be positive. Excess demand on their markets will lead to additional total foreign imports, i.e., to increasing German exports.

The remaining exports to all other countries are modelled in the same manner. We use total world imports minus the imports of the seven countries (including FRG) to mirror the demand for German goods. The deviation of world imports from the corresponding trend values can be interpreted as an indicator of rationing on the world market.

From the above discussion the following equation for German exports emerges:

$$X_i = f_{x_i} \left(\underset{+}{Y^i}, \underset{+}{M^i}, \underset{-}{\frac{P_x}{P^i \cdot E^i}}, \underset{-}{\frac{P_x}{P_x^w}}, \underset{-}{q - q^{\min}}, \underset{+}{(q - q^{\min})^i} \right) \quad (32)$$

To allow for dynamics we use a partial adjustment model. We tested for lags of order one to five and present the statistically significant lags. Error correction models are tested against partial adjustment models but with no superior results. All coefficients except those of the rationing variables can be interpreted as long-term elasticities because of using logarithmic values. We restrict the rationing coefficients to be equal in the short-run and in the long-run. Although we employed a TSLS-estimation for instrumenting the German rationing variable, only regressions of export to U.S. and UK turned out to be superior compared to OLS-estimation. The results are presented in table 1.

Exports to USA:

The estimates show the theoretically expected signs for all coefficients with the exception of the relative competitive price index which tends to be positive and is dropped therefore. Our results improve if we stick with the import demand variable and omit the income variable. The elasticity of exports with respect to demand is significantly higher but near unity (1.18), the relative price elasticity is not statistically different from minus unity (-1.02). The rationing variable for U.S. markets reveals a significant influence on German exports. The equivalent variable for the FRG shows the correct sign but with a high standard error.

¹³The ratio of domestic and foreign labour costs can serve as an alternative to measure the relative competitiveness. This might also be helpful to avoid any possible simultaneity between domestic and foreign price variables.

¹⁴See Baldwin (1990).

Exports to UK:

As for the USA we estimate TSLS and use lags of order one and four. All variables display the expected sign. The coefficient of the import demand variable shows a high value (2.54) which exceeds four if the demand variable for total imports is left out. The coefficient of the price variable is insignificant at the 10 per cent level and has a negative sign in several regressions. The foreign rationing variable has an elasticity of 0.16 which is low compared with the regressions for other countries with an elasticity of about 0.6.

Exports to France:

The results for exports to France wind up with a standard error of about 4 percent and show highly significant coefficients. Price elasticities are less than one. Only the German capital utilization variable is dropped because of a positive, albeit insignificant sign. The French rationing variable has the strongest influence on German exports (0.65). The mean time lag for adjustment is about one quarter.

Exports to Italy:

The results for Italy are similar to those for France. The coefficient of the foreign rationing variable has a significant influence on German exports. Only the relative price variable is less important (the price variable for international competitiveness has a positive but insignificant sign). The speed of adjustment is somewhat smaller compared to France.

Exports to Netherlands:

This regression shows the lowest standard error (0.037). As for the other exports there is a significant but somewhat less important influence of the foreign rationing variable, but less compared with the previous countries. The coefficients of both demand variables exhibit the same values as in the regressions for Italy. The elasticity of German exports with respect to total imports is less than one (0.88).

Exports to Belgium:

Exports to Belgium seem to have smaller price elasticities, whereas the demand coefficient reveal a high influence of Belgium income on German exports.

Table 1: Export Equations

Country i Variable	USA	UK	F	I	NL ^a	B	Others ^b
x_{i-1}	0.407 (5.40)	0.659 (9.23)	0.499 (7.27)	0.650 (9.80)	0.576 (6.79)	0.436 (5.38)	0.588 (8.03)
x_{i-4}	0.133 (2.18)	0.153 (2.28)		-0.077 (1.56)		0.171 (2.39)	
$q - q^{\min}$	-0.301 (0.75)	-0.560 (1.10)					
$(q - q^{\min})^i$	0.596 (2.05)	0.156 (2.80)	0.658 (3.16)	0.611 (2.71)	0.460 (2.14)	0.616 (2.61)	0.333 (2.33)
y^i		2.541 (2.24)	0.878 (2.51)	0.388 (1.65)	0.364 (2.45)	1.94 (9.75)	1.052 (41.51)
m^i	1.180 (32.51)	1.118 (1.52)	0.552 (2.97)	0.882 (5.58)	0.877 (8.13)	0.177 (2.51)	
$p_x - p_x^i$ $-e^i$	-1.021 (-7.89)	-0.656 (-1.55)	-0.621 (-4.67)	-0.404 (-3.40)	-0.776 (-4.36)	-0.237 (-2.06)	-0.119 (-3.29)
$p_x^i - p_x^w$		-0.795 (-1.82)	-0.382 (-3.85)		-0.183 (-1.44)	-0.544 (-3.65)	
\bar{R}^2	0.980	0.994	0.995	0.992	0.994	0.993	0.996
SEE	0.078	0.064	0.041	0.047	0.037	0.044	0.029
Q-Stat. (8 lags)	6.56	8.82	6.70	7.97	4.15	12.14	7.38

\bar{R}^2 : Adjusted R-squared; SEE: Standard error of regression.

t-values in parentheses, dummies are not presented.

Sample period 1960/1-1988/4

^aRegression with AR(1)-process (coefficient:0.183 (1.55)).

^bSee text for definitions.

Exports to all other countries:

All other German exports are well explained by world imports, relative prices and by world rationing. We obtain an elasticity with respect to world imports of 1.05 implying a constant share of German exports among world imports. In a recent study Entorf, Franz, König, Smolny (1989) estimate a slightly increasing share (1.15) of total German exports among total world imports. We also get a lower price elasticity (-0.12 compared with -0.21 by Entorf, Franz, König, Smolny) which may result from aggregation.¹⁷

The import equations basically have the same structure as the export equations. Both rationing variables are included and we expect signs opposite to the export equations. Increasing excess demand on German goods markets, represented by an increasing utilization of capital, should increase imports, whereas excess demand on foreign markets should have the opposite effect. As for exports we test two relative price variables, one reflecting the direct competition with German products and the other the competition with other imports. The first one is defined as the German price deflator divided by foreign export prices multiplied with an import tariff rate (t).^{18,19} The variable is zero after the abolition of taxes within the EEC in 1968. This relative price is expected to have a positive coefficient while the competitive price with other imports should have a negative sign. This variable is calculated as the general total price index (excluding the imports from the country examined) divided by the export price index of the exporting country.

$$M_i = f_{m_i} \left(Y, \frac{P}{P_x^i \cdot E^i \cdot (1+t)}, -\frac{P_x^w}{P_x^i}, q - q^{\min}, (q - q^{\min})^i \right) \quad (33)$$

+ + - + -

The empirical results are shown in table 2.

Imports from USA:

Imports from the USA are well explained by the German income variable (0.83), the competitive price variable to other imports (0.83) and the excess demand on the domestic market (0.80). We also find a negative although not significant sign for the excess demand on the U.S. market.

Imports from UK:

As for exports we find a slow speed of adjustment for imports. The estimated values for excess demand on domestic markets and for the income variable are not significantly different from unity which implies a constant share of UK imports. The

¹⁷We think of possible higher price elasticities between main economic countries which are not treated separately by Entorf, Franz, König, Smolny.

¹⁸This rate is an index, calculated from nominal total tariff revenues divided by nominal imports (from EC-countries). See Statistisches Bundesamt, Fachserie G, Reihe 2 "Außenhandel" Ergänzungsheft p. 125, 1967

¹⁹The import tax rate is dropped in the regressions for U.S. imports.

relative price variable is omitted because it has an unexpected negative sign. This might result from the influence of North Sea aggregate oil prices which are included in the total export price index of the United Kingdom but which might be of less importance for our imports. The Chow test reveals a structural break in 1974/1. For the period between 1960 and 1974 the relative price has its expected positive sign.²⁰

Imports from France and Italy:

The results for both countries are quite similar. Both regressions yield the same low standard error with less than 5 per cent and show equal speed of adjustments which are lower than for German exports into these countries. The elasticities with respect to relative prices display highly significant values of about one. Elasticities with respect to income which are considered above unity reflect the growing importance of the EEC. Excess demand in the FRG does not result in a shift to imports from France and has a smaller influence on imports from Italy, too.

Imports from the Netherlands and Belgium:

Both regressions yield the same mean time lag. The elasticities with respect to excess demand are about one. This mirrors the very close trade relations. As a consequence the economies of these countries are subject to spillovers stemming from excess demand on German goods markets. For the Netherlands this is also supported by high elasticities with respect to income (1.83).

Other imports:

Our results for total imports excluding the six countries show an income elasticity of 1.9. This result differs little from that of Entorf, Franz, König, Smolny (1989) despite the fact that we do not distinguish between imports of raw materials and other imports as these authors do. But this distinction might cause the different coefficient of relative prices (0.24) compared with 1.47 obtained by the authors mentioned above.²¹

In conclusion we note that in most regressions we obtain the theoretically expected sign of the coefficients of income, relative prices and direct competitiveness with home products.

The hypothesis that excess demand affects trade cannot be rejected. The market for German exports is subject to spillovers stemming from foreign goods markets. There is a strong influence of domestic market situations on German imports, too. We find little rationing on export markets as is evidence by insignificant coefficients.

²⁰We added a dummy in order to take account for the structural break but despite significance the coefficient did not change its sign. Using GNP price deflators and consumer prices for calculating the price ratio also do not yield the theoretically expected result.

²¹Raw materials show a low response to price changes. See Entorf, Franz, König, Smolny (1989) who obtain very low short-term elasticities (0.01) of raw material imports with respect to relative prices. Therefore, our result seems not to be implausible.

Table 2: Import Equations

Country <i>i</i> Variable	USA	UK	F	I ^a	NL	B	Others ^b
m_{i-1}	0.368 (4.89)	0.435 (5.32)	0.362 (5.17)	0.385 (4.71)	0.876 (22.66)	0.865 (22.26)	0.794 (10.74)
m_{i-4}		0.354 (4.92)					
$q - q^{\min}$	0.796 (2.85)	1.187 (4.06)	0.135 (0.85)	0.479 (2.15)	1.08 (3.48)	0.960 (3.54)	0.516 (2.64)
$(q - q^{\min})^i$	-0.228 (-1.07)						
y	0.826 (11.25)	0.997 (2.07)	1.535 (14.72)	1.628 (17.34)	1.833 (4.98)	1.036 (1.96)	1.917 (22.92)
$p_x - p_x^i$ $-e^i$	0.015 (0.10)	-0.912 ^c (-3.86)	0.996 (8.59)	1.030 (9.13)	0.805 (1.98)	1.607 (3.25)	0.244 (2.18)
$p_x^i - p_x^w$	-0.831 (-3.58)		-0.541 (-4.63)	-0.586 (-2.62)	-0.775 (-1.03)	-0.113 (-0.22)	
\bar{R}^2	0.932	0.989	0.993	0.993	0.992	0.993	0.994
SEE	0.076	0.080	0.048	0.048	0.057	0.051	0.036
Q-Stat. (8 lags)	5.67	22.45	10.15	12.71	35.58	10.74	7.05

\bar{R}^2 : Adjusted R-squared; SEE: Standard error of regression

t-values in parentheses, dummies are not presented

Sample period 1961/1-1988/4

^aRegression with AR(1)-process (coefficient:-0.42 (-3.52)).

^bSee text for definitions.

^cInfluence of the exchange rate only rather than relative prices.

This may be due to two reasons: Firstly, exporters try to keep their position on foreign markets because of high entrance costs and give some preference compared with their domestic markets. Secondly, a significant positive influence of the domestic capacity utilization rate ($q - q^{\min}$) on German exports can result from simultaneous equation errors between exports and capital utilization, a fact which is not surprising for Germany with an export share of about 30 per cent.

III.5 Exchange Rates

In order to take into account transmissions of monetary and/or fiscal measures which run via exchange rates, we have attempted to model the behaviour of important exchange rates. Relative prices which proxy the competitiveness of German exports and foreign imports are the main explanatory variables for trade. While foreign prices measured in their home currencies are treated as exogenous, the remaining two components, domestic GNP deflator and export prices and the respective exchange rates are explained within this model.

Since in the Bretton Woods system exchange rates have been constant for longer periods we consider only the period following the breakdown of Bretton Woods. The time series of nominal and real DM/\$- and DM/£-exchange rates²⁵ have moved in a close relation at least since the late seventies. Exchange rates of countries belonging to the "Snake" (1973-1979) or the EMS (since 1979) show a different pattern. While there have been only small movements of real rates (the exception is the real Dutch guilder which exhibits a strong real appreciation between 1974 and 1977) nominal rates devalued until the beginnings of the eighties. Rates are stabilized during the eighties.

In a model based on quarterly data we cannot explain very short-run exchange rate movements but only fundamental "trends" originated by basic economic variables. The explained exchange rates correspond to our trade equations with Belgium as an exception.²⁶

Needless to stress that estimates of exchange rates of different regimes are difficult because of possible misspecifications such as neglecting central bank interventions or ignoring the role of "news" or of non-linearities of exchange rates, to mention only a few objections. Of course, we think that central bank interventions influence actual rates and keep them within ranges around their parities but interventions seem to delay necessary realignments.

Our exchange rate model is based on asset market models with sticky price adjustment developed by Dornbusch (1976) and Frankel (1979).²⁷ These models assume perfect capital mobility and perfect substitutability between foreign and domestic assets. They are extended by Hooper and Morton (1982) who allow for changes in the real exchange rate. We assume purchasing power parities to hold in the long run. Equilibrium exchange rates are determined by money market conditions in the countries under consideration. Relative money supplies, relative GNP

²⁵Real exchange rates are calculated by deflating nominal rates with the ratio of foreign consumer prices to domestic consumer prices.

²⁶Over the whole period only rates for U.S. and United Kingdom have been floating while rates for France and Netherland have been fixed (or floating within definite small range) except for some small periods in the seventies. The rate for Italy floated in the seventies and has been fixed since the creation of the EMS.

²⁷See also Gaab (1982).

(Y) and the interest rate (R) differential (which equals the inflation rate (Δpc) differential in equilibrium) determine the nominal exchange rate. Hooper and Morton add the real exchange rate as a fourth variable. Following these authors the equilibrium value of the real exchange rate determines the equilibrium current account.²⁸ Unexpected movements in the current account (TB) causes the individuals to correct the equilibrium real exchange rate. By making use of a regressive expectations process, the real rate is related to unexpected movements of the current account and to the real exchange rate of the base period (q_0). Assuming uncovered interest parity, the short run behaviour is determined by the expected change of the exchange rate which equals the interest differential. Due to sticky prices the adjustment to long run values does not occur simultaneously. This process is modelled by adaptive expectations. Combining these three parts (the money market conditions, the determination of the real exchange rate and the slow adjustment process) leads to the following exchange rate equation:

$$e^i = f_{e_i} \left(\underset{+}{m1 - m1^i}, \underset{-}{y - y^i}, \underset{+}{\Delta pc - \Delta pc^i}, \underset{-}{R - R^i}, \underset{-}{\sum_{j=0}^t TB_{t-1}^i}, q_0 \right) \quad (34)$$

The signs of the partial derivatives are denoted below the variables in question. With the exception of the result for the current account all other signs are standard textbook results for models with slow adjustment on good markets. With respect to the current account its negative sign follows from the implications of expectations concerning the equilibrium value of the real rate which determines the equilibrium current account. Unexpected changes in the current account directly affect the expectations of the equilibrium value of the real exchange rate which moves in line with the nominal rate.

The estimation period is divided into two subperiods, the first period (1974/1–1979/2) starts after the breakdown of the Bretton Woods system and ends with the creation of the EMS, the second subperiod covers the time span until 1988/4. Dynamics are captured by a partial adjustment model. The variables are: money supply $M1$, GDP data for UK and Italy, GNP data for U.S., France and Germany. In the absence of quarterly data for the Netherlands, we proxy y by industrial production data. Long term interest rates (Government Bond Yield) R_t are used rather than short term rates. This reflects the importance of long term rates for investment decisions abroad.²⁹ In order to proxy expected inflation rates we employ either actual inflation rates of consumer prices or money growth rates.

The influence of cumulating foreign reserves is modelled either by trade account balances or by current account balances. The latter variable improves the regressions

²⁸The equilibrium current account is voluntarily accepted by the individuals. It is not necessarily zero.

²⁹Three-month interest rates were tested in several regressions but did not yield superior statistical results.

only for the French franc and the Italian lira whereas the former is used for other regressions. We have also experimented with total balances (rather than bilateral balances) of each country to take account the international demand for a currency despite that bilateral trades do not necessarily give an exhaustive explanation of bilateral exchange rate determination. Cumulated balances are deflated with German GNP data.³⁰

Because of a possible endogeneity of interest rates, we also used TSLS estimation rather than OLS but with negligible differences. The "seemingly unrelated regression" method was tested but it did not yield better results. Therefore, only OLS estimation results are reported in table 3 and 4. In the regressions for EMS currencies we also used Bundesbank intervention data to take into account managed floating rates. The results are very sensitive with respect to different sample periods, therefore we view them as not reliable. This might reflect the inadequacy of the data for our model and the non-availability of corresponding foreign data.³¹

The importance of each explanatory variables varies between countries. For the U.S. dollar the results of the first period (74/1–79/1) display a significant influence of total cumulated U.S. trade balances and the expected inflation differential. Bilateral balances have no impact which can be explained by the international importance of the U.S. currency. For the second period (79/2–88/4) we obtain the expected signs for all variables (except for balances).

The results for the UK currency improve for the first period if relative money supply is replaced by the relative price ratio.³² For the first sample the regression yields a long run coefficient of the price ratio which is not statistically significant different from unity. This corresponds to the purchasing power parity. For the eighties this theory does not hold. In this period we observe a real appreciation of the DM/£ rate probably due to North Sea oil.³³ The results improve if a variable for North Sea oil prices $p_{\bar{o}_t}$ is added. Moreover, two dummies (not reported) take into account the fall of oil prices and the dollar depreciation in 1985. Trade balances contribute to an explanation of the DM/£ rate only in the second period. Somewhat surprisingly, the coefficients of the interest differential yield a significant positive sign in both periods. This might result from an insufficient distinction between inflation differential and interest differential³⁴ or from the endogeneity of interest rates as a consequence of international interest links.

For the French franc and for the Italian lira price ratios have a significant impact on the determination of the exchange rate during the first period. While we cannot reject the coefficient being different from unity for France, the respective coefficient

³⁰When employing total balances we deflated with the corresponding GDP data.

³¹The employed data (changes in foreign exchange reserves, interventions in the DM/\$ market and in the EMS) are published in Geschäftsbericht der Deutschen Bundesbank.

³²We employ consumer price indices.

³³Regressions with price ratios yield coefficients which are statistically different from unity.

³⁴The results do not change when using the real interest differential.

Table 3: Exchange Rate Equations

Country i	U.S.A.		UK	
Period Variable	I	II	I	II
$(m1 - m1^i)_{-1}$		0.473 (2.27)		
$(p - p^i)_{-1}$			0.365 (1.94)	
$(\Delta pc - \Delta pc^i)$	0.016 (3.52)	0.014 (2.57)		0.637 ^a (4.40)
$R_t - R_t^*$		-0.024 (-2.85)		
$y - y^*$		-0.890 (-1.43)		
$\sum_t TB_{t-1}$	1.411 ^b (12.92)	-0.307 (-0.85)		-0.020 ^c (-2.71)
$P\bar{O}_t$				0.075 (2.22)
e_{-1}^i		0.769 (8.37)	0.660 (3.91)	0.546 (6.61)
\bar{R}^2	0.946	0.947	0.967	0.958
SEE	0.026	0.045	0.033	0.030
Q-Stat. (8 lags)	4.45	9.19	8.13	11.13

See the following table for explanations.

^aGrowth rate differential of money supplies

^bCumulated total U.S. trade account

^cNon cumulated bilateral trade account

for Italy is greater than one. For the EMS period money supply variables improve the results compared with price ratios. In both periods current account balances, lagged one period, exhibit their theoretically expected signs. For the French franc current account balances display a stable influence on the exchange rate. In the regressions for the DM/Lira exchange rate cumulated current account balances for the first period and cumulated trade account balances for the second period yield more plausible results.³⁸ The GDP ratio variable is lacking its influence on exchange rate determination in partial adjustment specifications. As in the regressions of the DM/£ rate, the nominal and real interest differentials have no significant influence on both exchange rates. This may result from financial restrictions but can also be

³⁸The coefficient does not change when the lagged endogenous variable is omitted.

due to the endogeneity of the interest rates.³⁹

The results for the Netherlands yield a stable influence of money supply ratios in both periods. Only in the EMS period the coefficient of the interest differential exhibits its expected sign.

In conclusion we note that the variables like money supply ratio or price ratios have explanatory power in both periods. For the European rates other variables contribute only little to an explanation, whereas in the case of the U.S. dollar the influences derived from theory are more likely to be confirmed by the estimates.

Table 4: Exchange Rate Equations—Continued

Country <i>i</i>	F		I		NL	
Period Variable	I	II	I	II	I	II
$(m1 - m1^i)_{-1}$		0.077 (2.66)		0.173 (3.94)	0.150 (2.66)	0.090 (2.31)
$(p - p^i)_{-1}$	0.319 (14.13)		1.403 (20.01)			
$R_t - R_t^i$						-0.012 (-4.63)
$\Delta pc - \Delta pc^i$			0.424 ^a (6.48)			
$\sum_t TB_{-1}$	-0.062 ^b (-3.65)	-0.012 ^c (-3.69)	-4.160 ^d (-1.93)	-0.808 (-1.96)		-0.791 (-1.84)
e_{-1}	0.642 (4.93)	0.860 (26.44)		0.710 (8.33)	0.859 (7.06)	0.580 (5.18)
\bar{R}^2	0.924	0.992	0.992	0.9995	0.737	0.894
SEE	0.029	0.013	0.020	0.012	0.010	0.004
Q-Stat. (8 lags)	4.21	6.73	6.30	6.43	4.99	5.06

I: 74/1-79/1; II: 79/2-88/4

R^2 : Adjusted R-squared; SEE: Standard error of regression

t-values in parentheses, dummies are suppressed.

^aGrowth rate differential of money supplies.

^bNon cumulated current account balance

^cNon cumulated current account balance

^dCumulated current account

³⁹See also Kirchgässner and Wolters (1989) who do not find support for the validity of uncovered interest parity between European countries.

III.6 Output and Employment

After the treatment of exports (XD) and imports (MD) we are now able to determine total demand (YD) which is derived from output (YT) and corrected for the difference between effective (XT, MT) and structural trade:⁴⁴

$$YD = YT + (XD - XT) - (MD - MT) \quad (35)$$

Using our estimates of productivities, we can derive goods supplied determined by employment (Y_{LT}), labour demand determined by expected goods demand (L^*) and labour demand brought about by capacity output (L_{YC}).

We first turn to the estimations of the CES-functions of output (eq. 16) and of employment (eq. 17), presented in section II. There are two possibilities to model the mismatch parameter. Firstly, the mismatch parameters can be treated as endogenous variables. This approach is not pursued here because at this stage no explanatory variables for the mismatch parameters turned out to be satisfactory. The second option is to estimate the equation together with an additional error term. We capture the mismatch parameter with time trends and dummy variables. This procedure is, of course, entirely a data analysis and must be replaced by economic analysis in the next step of this project. In the equation for output we include two dummies for the following reason. In 1970 (1982) the degree of capital utilization was at its maximum (minimum) which leads to the strict minimum condition of the CES-function ($\rho_1 \rightarrow \infty$). These extreme values of DUC are corrected by dummies. The coefficient associate with YD corrects for measurement errors in the data.

$$YT = \left\{ Y_{LT}^{-\rho_1} + [(1 - 0.002) YD]^{-\rho_1} \right\}^{-\frac{1}{\rho_1}} \quad (36)$$

(-3.27)

$$+ 1.44 \cdot D702 + 1.22 \cdot D823$$

(2.95) (2.41)

$$\text{with } \rho_1 = -73.17 + 0.603 \cdot t - 0.003 \cdot t^2$$

(-15.25) (5.28) (-3.71)

$$R^2 = 0.999; \quad SEE = 0.476; \quad Q\text{-Stat. (8 lags)} = 50.08$$

$$\text{Sample } 60/1 - 88/4$$

The fitted time trend of ρ_1 exhibit a growing mismatch on the goods market with a slightly slowdown.

⁴⁴Because of our assumption that domestic excess demand is satisfied by additional trade, transacted consumption and investment equal demand. Consumption and investment only differ from their respective structural values when excess demand appears on the world markets and on the domestic market at the same time. This rare case is neglected in our model.

In the estimates for employment we try to capture the mismatch parameter ρ_2 by time trends analogous to the goods market. Better results are obtained with dummy and time trend variable, however. Four dummies are included to allow for peaks in employment: the recessions 1967 (D671) and 1975 (D751, D753) and 1983 (D823).

$$LT = \left\{ LS^{-\rho_2} + \underset{(14.55)}{[(1 + 0.039) L_{YD}]^{-\rho_2}} + L_{VC}^{-\rho_2} \right\}^{-\frac{1}{\rho_2}} \quad (37)$$

$$+ \underset{(4.30)}{0.392 \cdot D671} + \underset{(5.26)}{0.239 \cdot D751} + \underset{(2.75)}{0.456 \cdot D753} + \underset{(2.58)}{0.234 \cdot D823}$$

$$\text{with } \rho_2 = - \underset{(-33.22)}{40.25} + \underset{(9.64)}{12.72 \cdot D75} + \underset{(4.29)}{5.24 \cdot D83} + \underset{(0.93)}{0.0002 \cdot t^2}$$

$$R^2 = 994; \quad \text{SEE} = 0.082; \quad \text{Q-Stat. (8 lags)} = 40.24$$

$$\text{Sample } 60/1 - 88/4$$

III.7 Interest Rates

Despite the difficulties of a period of 29 years with different monetary targets and exchange rate regimes we estimate an equation with a three-month interest rate as dependent variable. This implies that we treat the German money supply as exogenous. This is, of course, an oversimplification since in the Bretton Woods-system money supply is more an endogenous variable determined by factors such as (domestic) inflation and the like. Although we experienced a mixed exchange rate system following Bretton Woods (the "Snake" and the EMS) we think that the German Bundesbank, by and large, was not totally unsuccessful in controlling the money supply.

In our model the short-term interest rate is determined by the real money supply (nominal money deflated by the GNP deflator), real GNP (deflator as before), the foreign three-month interest rate and the expectation of its corresponding exchange rate changes (Δe^e) to cover international linkages between interest rates.⁴⁵ We use the short-term U.S.-Euromoney market interest rate and the expected change of the U.S. exchange rate.⁴⁶

⁴⁵See Kirchgässner, Wolters (1989) who find strong support for domestic money market rates linkage between Europe and the U.S. and especially between U.S. and Germany. While linkages are found for both exchange rate regimes, there is only weak support for the validity of uncovered interest parity.

⁴⁶We also estimate standard textbook versions of domestic money market equations including foreign interest rates but these estimations do not reveal a significant influence of the foreign interest rate on money demand.

The following equation describes the functional form of the interest equation:

$$R = f_R(M, Y, R^{US}, \Delta e^{e, US}) \quad (38)$$

The sign of the partial derivative of the money supply is expected to be negative while all other signs should be positive.⁴⁷

The change of the exchange rate is used to proxy the expected change. In order to model the dynamics we test an error correction model against a partial adjustment version with superior results.⁴⁸

$$\Delta r = \text{const.} + 1.277 \Delta y - 5.611 \Delta m + 0.451 \Delta r^{US} + 0.451 \Delta^2 e^{e, US} \quad (39)$$

(2.43) (-6.56) (4.95) (0.89)

$$- 0.310 (r_{-1} - 2.508 y_{-1} + 2.395 m_{-1} - 0.474 r_{-1}^{US} - 0.450 \Delta e_{-1}^{US})$$

(5.17) (2.62) (-3.02) (2.87) (0.40)

$$\bar{R}^2 = 0.555; \quad \text{SEE} = 0.114; \quad \text{Q-Stat. (8 lags)} = 11.80$$

$$\text{Sample } 60/1 - 89/2$$

The regression reveals a slow adjustment process to long-term equilibrium values. Compared to domestic money demand regressions we measure fairly standard long-run elasticities (1.05) of money demand with respect to real GNP. The elasticity with respect to interest rate seems to be high (-0.42).^{49,50}

The insignificance of the exchange rate changes might result from incorrect modelling of expectations of exchange rate changes (Δe^e). Experiments with different lags of exchange rate change did not yield plausible results.

III.8 Wages and Prices

The development of wages is mostly a result of a centralized bargaining by the two parties in the labour market, the labour unions and the employers. The main issues in the negotiations about the wage rate are the protection of real wages, the division of the produced surplus and the demand and supply conditions on the labour market.

⁴⁷Expected inflation should also have a positive influence on interest rates. We have tested for this hypothesis but with somewhat curious results. The short-term influence of the inflation is negative and in some regressions the long-term coefficients of GDP and real money loose statistical significance. This approach will be due to further work.

⁴⁸See Rüdél (1989) who tests the hypothesis of no-cointegration of money supply, GNP and short-term interest rate. The author estimates German money demand during the period 61/4 to 87/4 with an error correction specification.

⁴⁹See Rüdél (1989), p. 98, who finds higher semielasticities with respect to the interest rate when estimating error correction models compared to static LS regressions.

⁵⁰In regression with non-log interest rate form we receive semielasticities of -0.092.

Employers are willing to accept wage increases if they expect an expansion of profits. The development of profits will be approximated in our estimates by the growth rate of unit labour costs ($\Delta w - \Delta(yc - l)$), where Δw denotes the growth rate of wages and $\Delta(yc - l)$ the growth rate of productivity. If the increase in productivity exceeds the growth rate of wages, the unions will claim higher wages for distributional reasons. Additionally, decreasing labour costs rise the margin for the employers to afford higher wages.

Since unions strongly refer to costs of living when demanding higher wages the development of the real consumption wage should be included in estimations which try to explain the development of the effective wage rate. On the other side, the wage variable employers are interested in, is the production wage which includes their output price and non wage labour costs. In taking care of these aspects we use a wedge variable in the estimation $wedge = \frac{W^T/P}{W^n/PC}$ where W^T denotes the total labour costs including employers non wage labour costs, P the GNP deflator, W^n net wages (effective wage net of payroll taxes and employees's payments to the social security system) and PC the consumer price index.

Some authors⁵¹ argue that the sole consideration of price and productivity variables in wage equations is the most suitable form to describe the behaviour of the participants in the wage bargaining process, which implies, however, that the wage reacts independently to supply and demand conditions on the labour market. This independence results in an absence of an equilibrating mechanism in the labour market. Taking account of equilibrium forces we add a measure of the excess demand on the labour market as an explanatory variable to the wage equations, which is derived from the estimation of the employment function and which can be interpreted as the proportion of firms constrained by actual labour supply.

In the Federal Republic of Germany wages are negotiated between unions and employers on the industry level and in most cases one industries's bargaining results become a reference point. The contracts of the leading industry are then the guiding principle in subsequent negotiations. We consider this leader-follower relationship by including fourth lags of the growth rate of wages into our wage equations.

The preceding considerations yield the following specification:

$$W = f_W(P, (PM/P), wedge, (yc - l), \epsilon_{LT,LS}) \quad (40)$$

where PM/P denotes the import price relative to the GNP price deflator and LC the regime of excess demand for labour. To discriminate between long and short run effects we use an error correction scheme. Finally seasonal dummies as well as two dummies for the autonomous wage push in 1969/4 and 1970/1 are introduced.

The price equation is formulated as a mark-up pricing rule. The change of prices is therefore mainly the result of the development of costs. The main determinants are

⁵¹ See Lipsey (1981) for example.

the development of wages and productivity, which affect prices in different directions. Further relevant cost components are import prices relative to the GNP deflator and the value added tax rate. In addition, we suppose that the mark-up factor is not constant over time but varies procyclically according to demand conditions on the goods market. This dependence is approximated by the inclusion of lagged capacity utilization⁵² into the estimated equation.

$$P = f_P(W, \text{TAX}, PM/P, DUC, (yc - l)) \quad (41)$$

where TAX is the value added tax rate and DUC denotes the rate of capacity utilization. We use an error correction specification, similar to the wage equation.

In what follows we present the estimates of the price and wage equations. Starting from the theoretical equations (40) and (41) we have tested several restrictions on the coefficients and added some more lagged variables to capture the dynamic properties of the equations using quarterly data. We obtained the following results:

$$\Delta w = \text{const.} + 0.093 \Delta w_{-1} + 0.924 \Delta w_{-4} + 0.102 \Delta \text{wedge} + 0.081 \Delta (pm - p) \quad (42)$$

(2.27) (24.02) (2.19) (2.11)

$$- 0.149 (\Delta w - \Delta p - \Delta (yc - l))_{-1} - 0.074 (w - p - (yc - l))_{-1}$$

(4.00) (3.09)

$$+ 0.034 \text{wedge}_{-1} + 0.020 \epsilon_{LT, LS_{-1}}$$

(1.69) (1.86)

$$\bar{R}^2 = 97.6; \quad \text{SEE} = 0.009; \quad \text{Q-Stat. (8 lags)} = 16.63$$

Sample 60/1 – 88/4

$$\rho(1) = -0.345 (3.67); \quad \rho(4) = -0.364 (3.94)$$

$\rho(i)$: correction term with respect to autocorrelation of order i .

Due to the strong seasonality in the data it is necessary to correct the equations for first and fourth order autocorrelation.

In the short run wage growth is mostly affected by the development of prices, unit labour costs and the wedge between product and consumption wage. Demand conditions on the labour market are of minor importance in the short run. We find no significant influence of the labour constrained regime. Furthermore, in the long run there is a one to one correspondance between prices and unit labour costs. The same coherence can be found in the wage equation where a coefficient of unity for prices and productivity is estimated.

⁵²In an alternative regression we used a measure of the regime of excess demand for goods, which had been calculated from CES-function of the goods market as described above. This leads to comparable results in the coefficients but higher standard errors of the coefficients.

The low value of the error correction terms in both, the price and the wage equations, points out that wage and price behaviour is very sticky. As far as wages are not equal to their steady state values, only seven percent of this deviations are reduced in the subsequent period. The corresponding figure in the price equation is three percent.

$$\Delta p = \text{const.} + 0.136 \Delta w_{-1} - 0.063 \Delta w_{-4} - 0.115 \Delta w_{-5} + 0.751 \Delta p_{-4} \quad (43)$$

(2.47) (-1.16) (-1.98) (9.10)

$$+ 0.081 (\Delta w - \Delta(yc - l)) + 0.062 \Delta(yc - l)_{-1} + 0.054 \Delta DUC_{-1}$$

(1.85) (1.69) (1.66)

$$+ 0.076 \Delta(pm - p)_{-1} + 0.593 \Delta TAX$$

(2.38) (1.58)

$$- 0.028 (p_{-1} - 1.078 (w - (yc - l))_{-1}) + 0.043 DUC_{-1}$$

(1.00) (12.16) (3.14)

$$\bar{R}^2 = 78.3; \quad SEE = 0.0006; \quad Q\text{-Stat. (8 lags)} = 5.26$$

Sample 60/1 - 88/4

$$\rho(1) = -0.271 (-2.66); \quad \rho(4) = -0.313 (2.97)$$

$\rho(i)$: correction term with respect to autocorrelation of order i .

III.9 Regimes on the Goods and the Labour Markets

With the estimated mismatch parameters for the goods market and for the labour market (see eq. 36 and 37) we are now in a position to calculate the share of firms constrained either by demand or by supply variables.

Figure 1 displays the shares on the good markets. The plot reflects the economic situation in the FRG during the period under consideration and shows peaks of the shares of the excess supply regime in the recession 1967 and after OPEC I while smaller shares of this regime are observed in the boomphase of 1970 and during the recent history. The calculations of firms being constrained either by labour supply, goods demand or capacities follow equations (16). Figure 2 presents our estimates of different regimes on the labour market. The plots show a substantial share of labour supply constrained firms in the sixties until OPEC I with the exception of the short recession 1967. After 1974 the labour supply regime loses its dominance. We observe an increase of this regime only during the economic recovery from 1976 until 1980. After OPEC I the goods demand constrained regime has been the major regime on the labour market, although there has been a notable decline since 1984.

With the recession 1967 as an exception, the share of capacity constrained firms

was more or less constant until the first oil price shock. Afterwards, we observe a greater variability of this regime.

An interesting feature of these plots is that they indicate wage and price rigidities. Although there was a long lasting excess demand for labour until 1974⁵³ no tendency to equilibrate the labour market by raising wages took place. Similar considerations hold for the labour market in the eighties with no wage declines in order to remove the persistent high unemployment and for the goods markets where demand constrained regimes do not decrease soon which might indicate price rigidities.⁵⁴ The large share of firms constrained by demand heavily attributes to the high unemployment rate in the FRG. Employment follows the minimum of (LS, LC, L_{YD}) which has been characterized by L_{YD} since the mid of the seventies, (see figure 3).

Lower investment activity reduces capacities and increase the share of firms constrained by a lack of production capacities which can be observed between 1975 and 1979 and clearly from 1982 onwards. On the other side, since 1984 increasing capacity utilization has presumably caused the investment boom today. A similar situation took place in 1970 when capacity utilization was at its maximum and increasing investments raised the production capacities.

⁵³The break down in 1967 was likely to be too short to be of greater importance.

⁵⁴These findings correspond to our estimation results, where demand conditions only contribute little to wage and price determination at least in the short run.

Figure 1: Regime Shares on the Goods Market

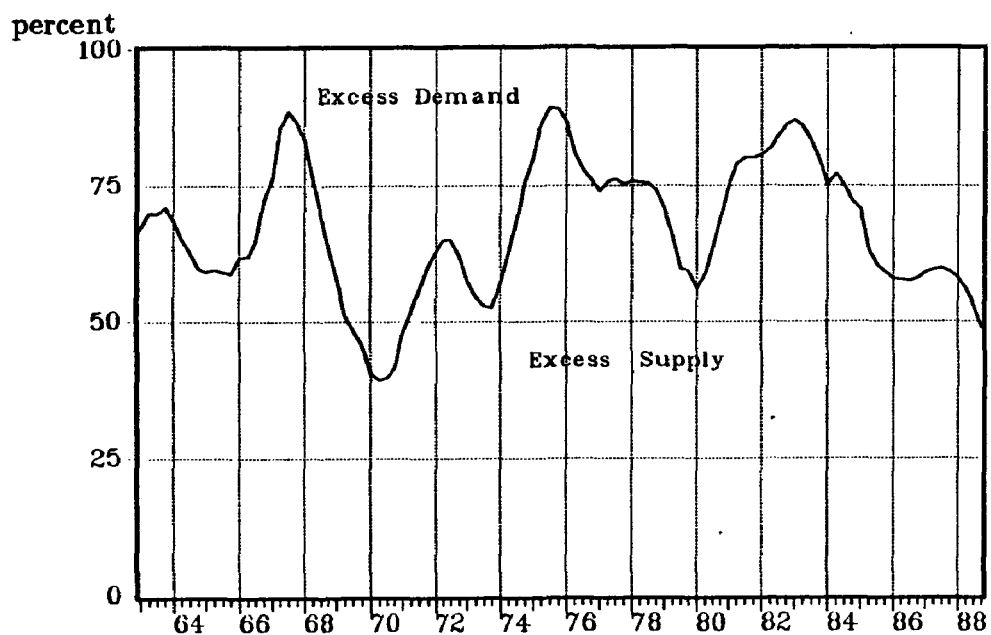


Figure 2: Regime Shares on the Labour Market

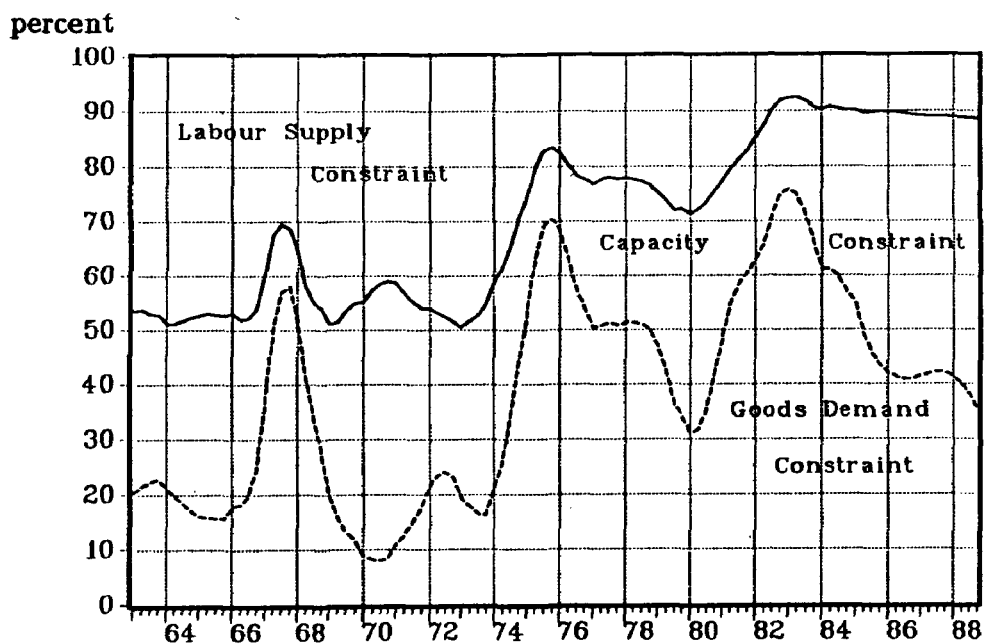
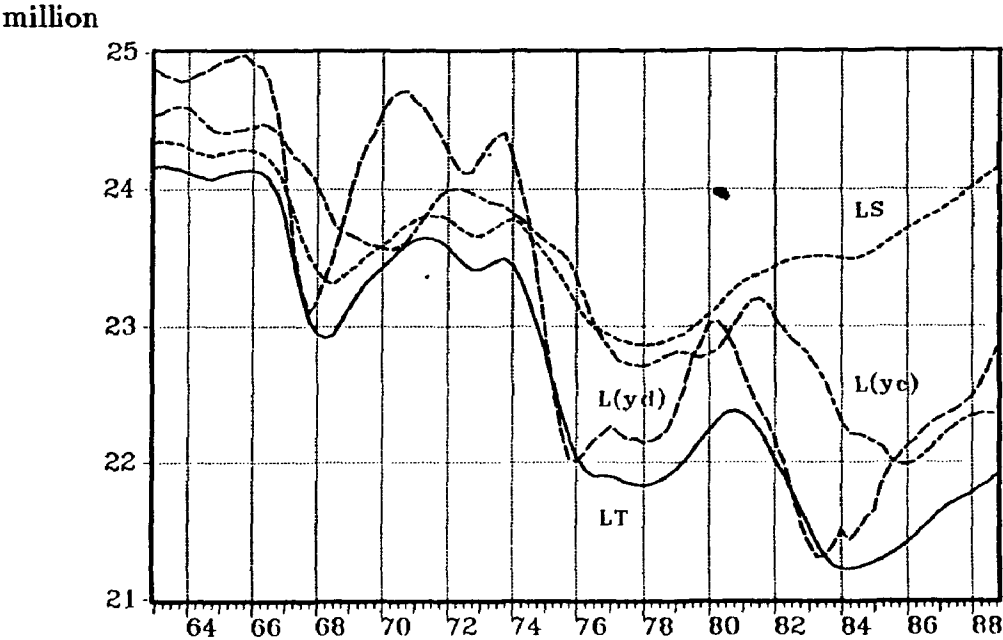


Figure 3: Employment Series



IV Simulation Results

In order to evaluate the dynamic properties of the non-linear model, we simulate the model in the period 1963/1 to 1988/4. With the exception of the relative price of investments all endogenous variables are simultaneously determined.

Table 5 presents the correlation coefficients between the baseline solutions of the simulation and the actual development as well as the percentage root mean square errors of the main variables of the model. The simulation reveals high correlations between trended variables like output and trade variables whereas non-trended variables do not perform as well. Especially, changes in the GNP-deflator, the interest rate and the utilizations rates of *DUC* and *DUL* show lower correlation coefficients.

More specifically, we observe that the simulated structural export and import series follow their actual series rather closely. Structural imports are underestimated during the period 1968 to 1973 and during 1981 to 1987, for example. Two reasons are mainly responsible for this performance of the imports. Firstly, it is plausible that the strong underestimations of the capital utilization rate have caused this result. The second reason may be the relative import price variable which performs satisfactorily only for the sixties. Since 1970 relative import prices are heavily overestimated. Nevertheless, most of the peaks of the actual and simulated series occur at the same time. The underestimation of the imports may not so much be traced back to the simulated exchange rates which perform quite well.

The simulated exports perform better. The influence of *DUC* on export is only weak compared to the influence on imports. The underestimation of simulated imports lead to an overestimation of the trade balance. But despite the lower values of the trade balance the simulated series follows the actual series between 1981 and 1985 which is increasing.

The unsatisfactory behaviour of the simulated relative import price variables is solely due to the simulated GNP deflator which underestimates its actual value between 1970 and 1981 and which remains constant from 1983 onwards despite the rise of the actual series.

The implications of the simulated prices on the short term interest rate seem to be large. We estimate a high short term influence of real money supply on the interest rate. From this the high underestimations, at the top by more than 4 percent, might follow. On the other side, when the simulated GNP deflator equals its actual value, i.e., when real money is simulated correctly, as it is the case for 1981, the actual and simulated interest rate reach their respective peaks on the same level.

An underestimation of the interest rates has some consequences on investment. Due to the slow adjustment of investments the simulated investments overshoot their actual values in the mid seventies. For instance, they do not respond adequately to the interest rate peaks 1970 and 1973/74. Capacity utilization rates are therefore overestimated. Consequently, employment is higher in the seventies.

We observe a similar development from 1983 onwards. Our simulations fit the actual values of labour demand, investments and capacity utilization in 1980/81 quite well but due to the importance of lagged variables the investment squeeze leads to a fall of the capital utilisation rate below its actual value in 1983 during the following years. Until the end of our simulation period employment is therefore underestimated in our model.

Figure 4: Employment

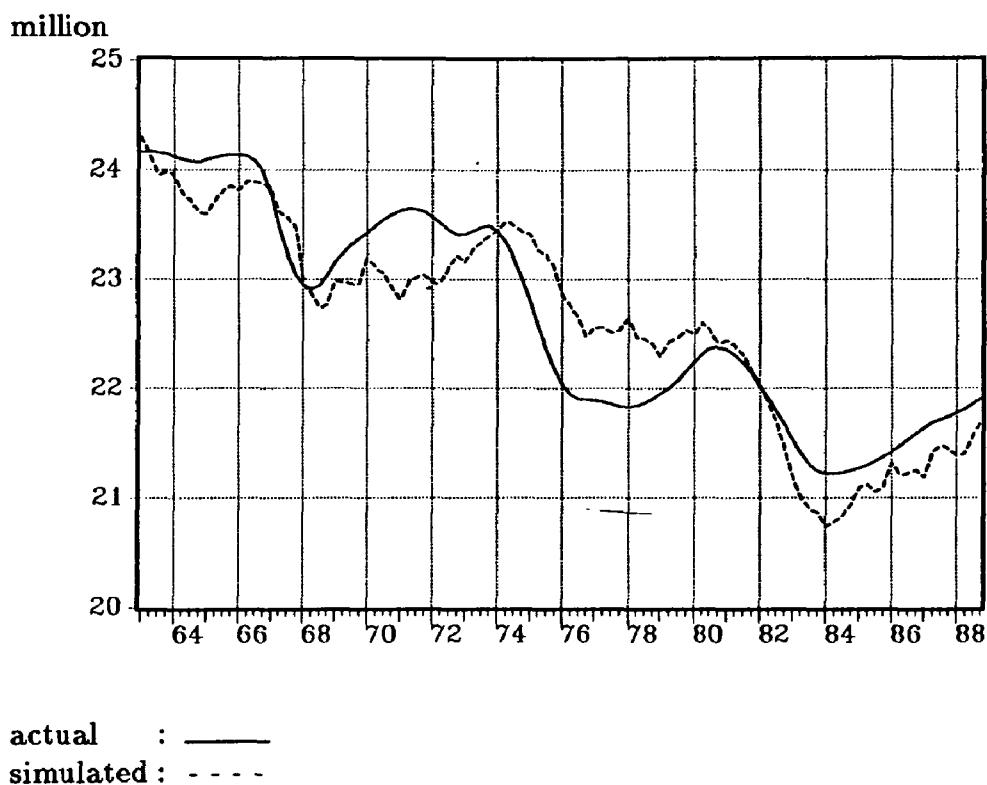


Table 5: Results of the Simulations

Variabel	RMSE% ^a	Corr
<i>LT</i>	0.02516	0.837
<i>LYD</i>	0.0585	0.619
<i>LYC</i>	0.0431	0.555
<i>UR</i>	0.0212	0.810
<i>YT</i>	0.0237	0.994
<i>YD</i>	0.0313	0.990
<i>C</i>	0.0280	0.994
<i>X</i>	0.0454	0.996
<i>M</i>	0.0787	0.986
<i>yc - l</i>	0.0248	0.997
<i>yc - k</i>	0.0262	0.973
<i>DUC</i>	0.0315	0.616
<i>DUL</i>	0.0158	0.393
Δk	0.0181	0.876
Δw	0.0252	0.913
Δp	0.0181	0.663
Δi	0.1685	0.585
<i>pm - p</i>	0.0731	0.790
e^{US}	0.0707	0.970
e^{UK}	0.0424	0.996
e^F	0.0222	0.998
e^I	0.0385	0.998
e^{NL}	0.0117	0.990

Corr: Correlation between actual and simulated series

RMSE% : Percentage root mean square error

^aRMSE are computed for the growth rates of *W* and *P* as well as for Δk , *I*, *UR*, (*yc - l*), (*yc - k*), (*pm - p*) and e^{US} , e^{UK} , e^F , e^I , e^{NL} .

Figure 5: Total Imports

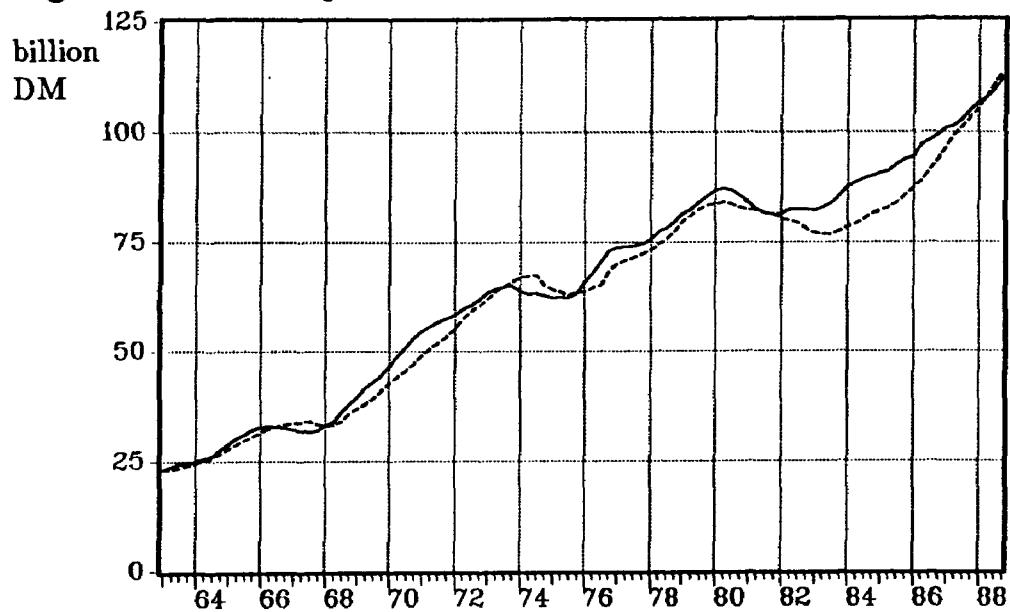


Figure 6: Trade Balance

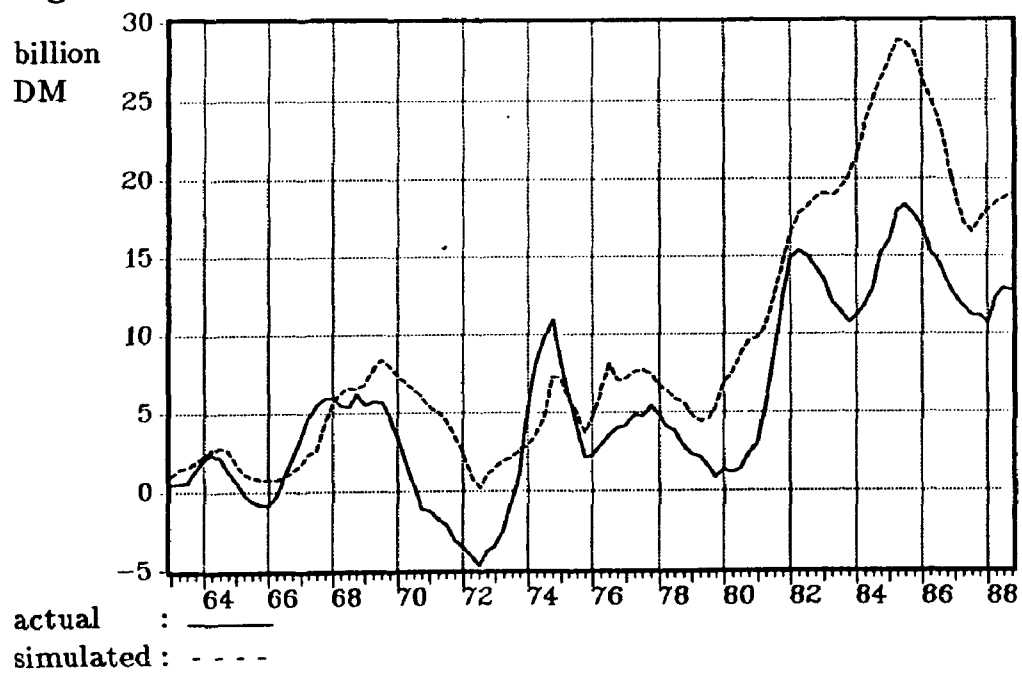


Figure 7: Degree of Capital Utilization (DUC)

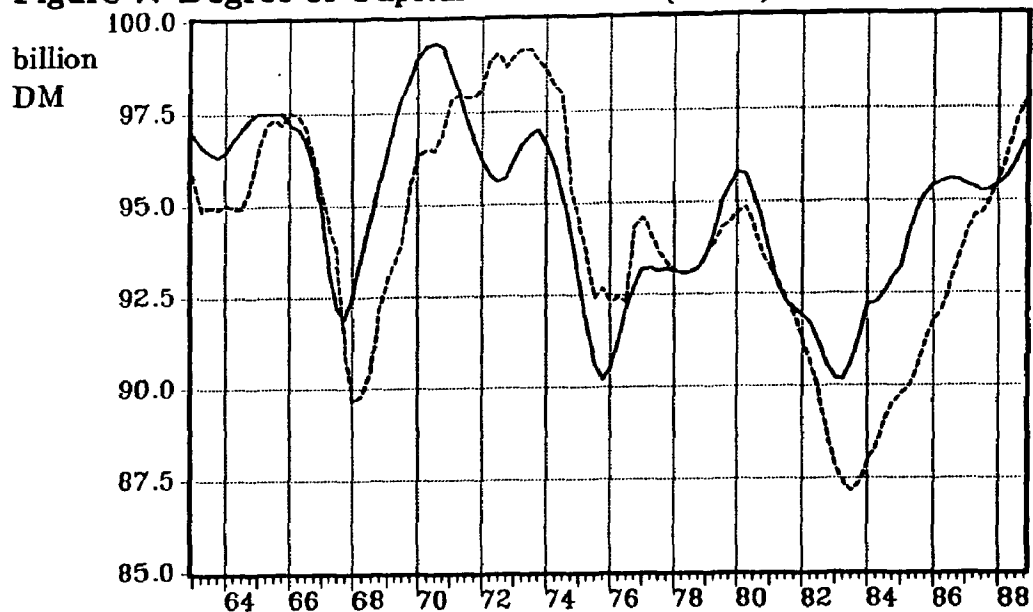


Figure 8: relative Import Price (P_m/P)

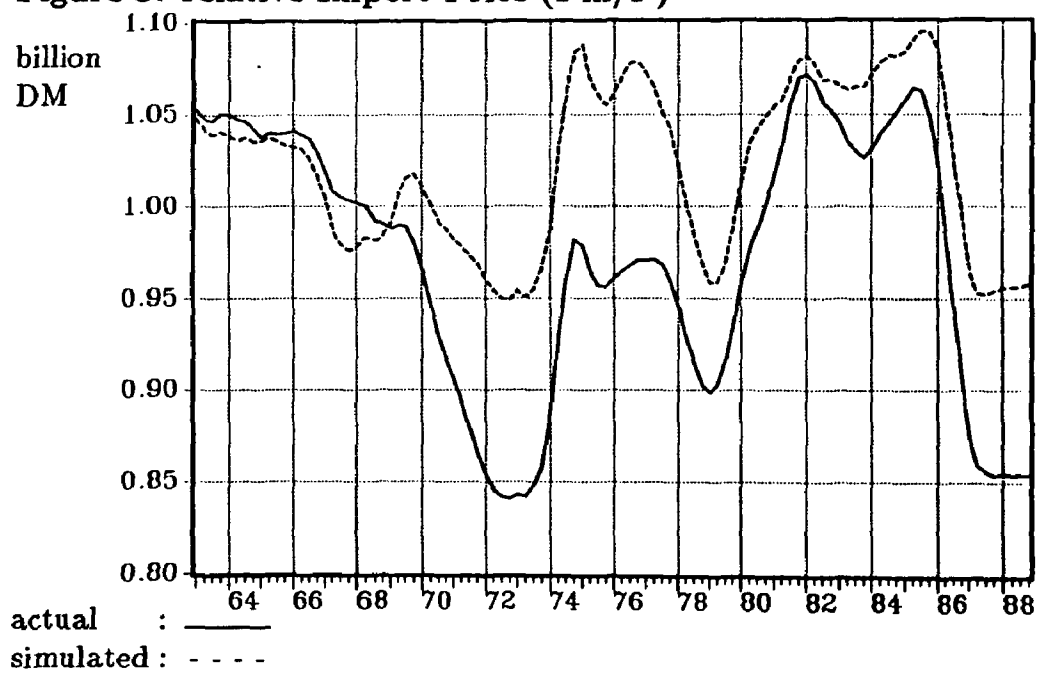


Figure 9: Short term Interest Rate

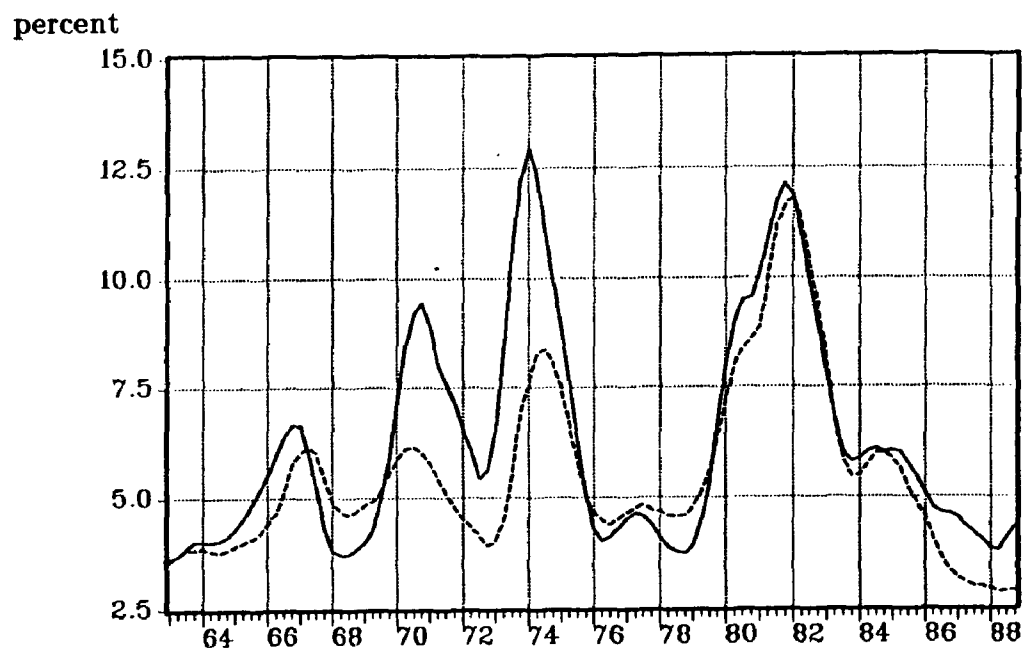


Figure 10: U.S. Dollar Exchange Rate (DM/\$)

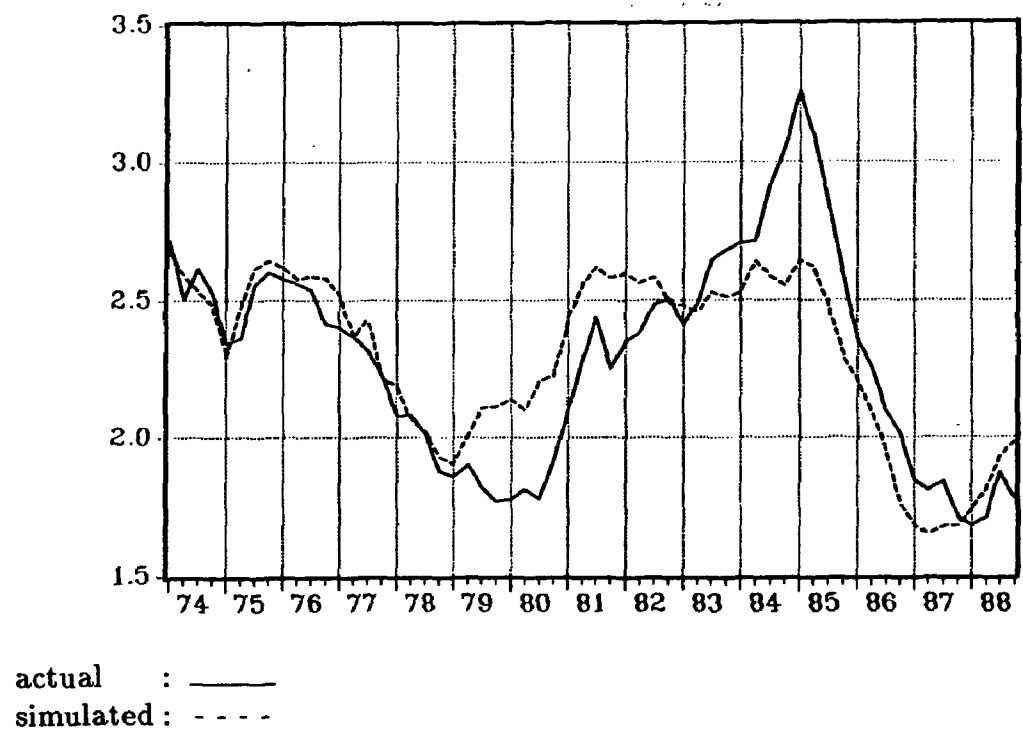


Figure 11: UK Exchange Rate (DM/£)

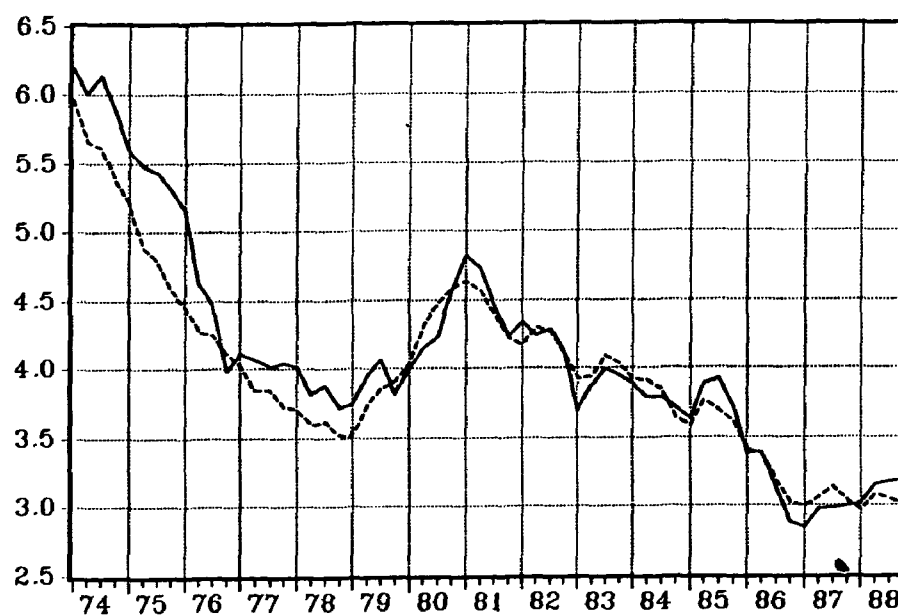
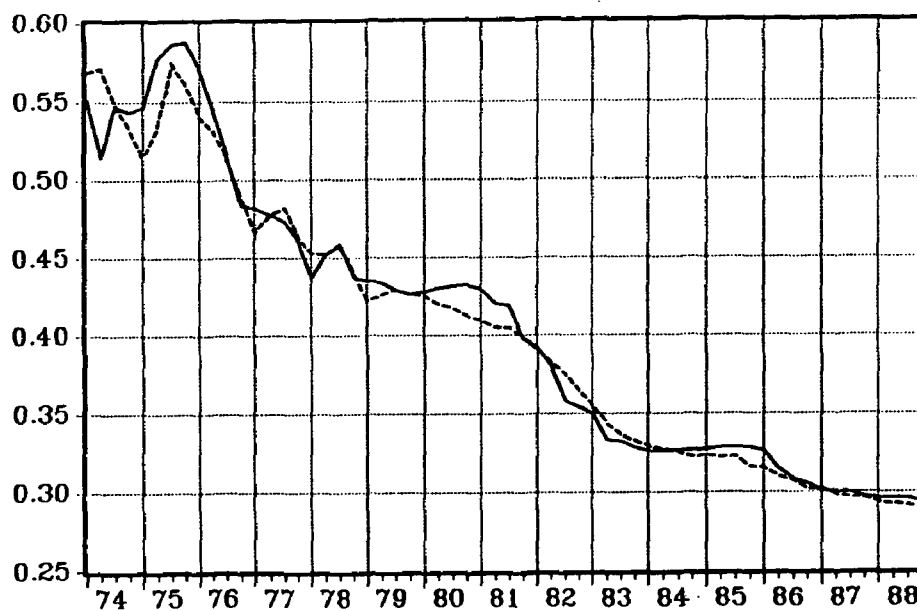


Figure 12: French Franc Exchange Rate (DM/FF)



actual : —
 simulated : - - - -

Figure 13: Italien Lira Exchange Rate (DM/1000 Lit)

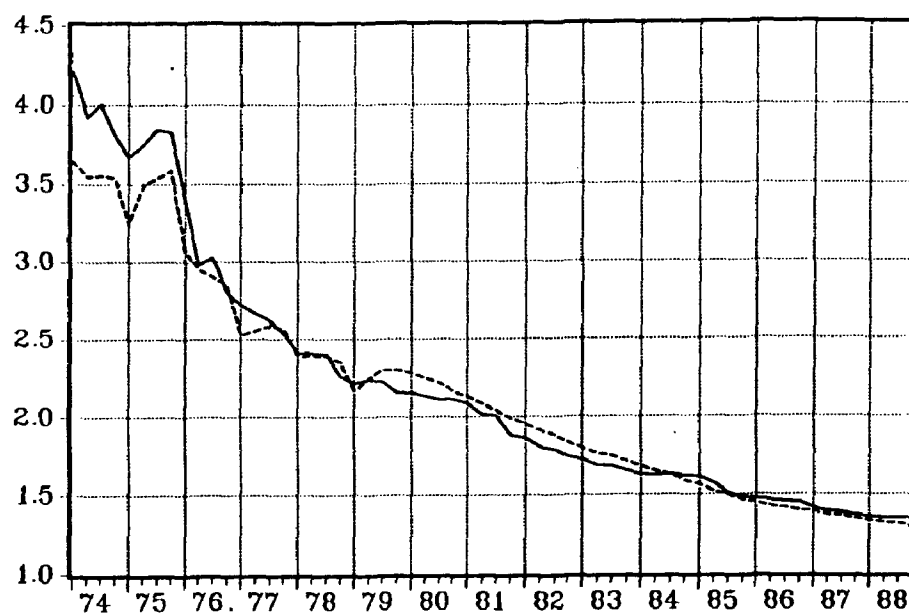
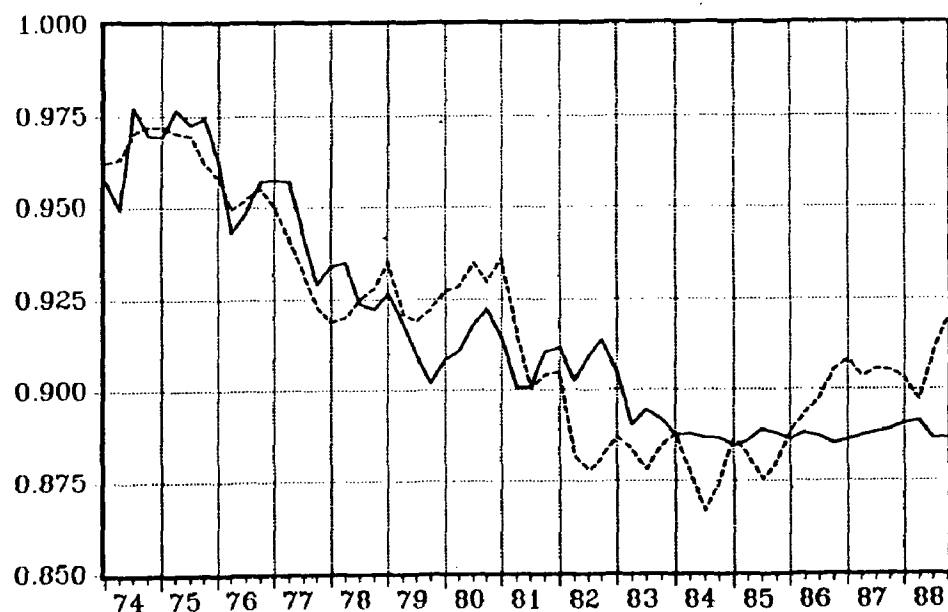


Figure 14: Dutch Guilder Exchange Rate (DM/Hfl)



actual : ———
simulated : - - - -

V Conclusions

The modest aim of this paper was to evaluate the importance of rationing in a disequilibrium model for an open economy. More specifically, a special reference was given to trade flows and it was investigated to what extent domestic demand in foreign countries and/or foreign demand on the domestic market was hindered by high capacity utilisation rates. On the other hand, the possibility that, for example, domestic rationing can be (partly) circumvented by imports was also subject to econometric tests. By and large, we found empirical evidence that the domestic export market is influenced by spillovers stemming from foreign goods markets and, moreover, that parts of the domestic import demand reflects the attempt to bypass domestic rationing barriers on the goods market. However, there was little if any evidence that German exports were rationed due to a lack of world demand. Moreover, our results are in accordance with the more recent consideration about hysteresis in trade. The influence of the domestic capacity utilization rate on exports is much lower than on imports. Hence, firms will not give up foreign markets even if domestic market conditions improve.

As has been emphasized several times this study represents a first step for a broader investigation on the importance of international linkages in a multi-market disequilibrium framework. It suffers from several imperfections which we hope to remedy in further studies. Hence, our list of caveats is rather long and has been outlined in the preceding sections. Most importantly, not only is the link between the theory of exchange rate determination and our estimated equations weak, but also the treatment of different exchange rate regimes obviously needs further efforts. Due to a lack of data the trade equations also do not contain all the relevant variables dictated by theory. Finally, the data analysis concerning the mismatch parameters must be substituted by an economic treatment and international labour migration should be integrated in our model.

VI Appendix

Log logistic approximation for transacted labour:⁵⁶

$$F_{yd}(y_{LT}) = \text{prob}(y_{LT} < yd) = \frac{1}{1 + \exp\left(-\frac{\log Y_{LT} - E(\log YD)}{\alpha}\right)} \quad (44)$$

$$\text{with } \alpha = \frac{\sqrt{3} \cdot \sigma_{yd}}{\pi}$$

Assuming a log normal distributed variable YD we obtain for the expected value of YD :

$$E(\log YD) = \log E(YD) - \frac{1}{2} \sigma_{yd}^2.$$

Rearranging (44) and using the expected value for YD we obtain:

$$\begin{aligned} 1 + \exp\left(-\frac{\log Y_{LT} - \log E(YD) + \frac{1}{2}\sigma_{yd}^2}{\alpha}\right) &= \frac{1}{\text{prob}(Y_{LT} < YD)} \\ \exp\left(-\frac{\log Y_{LT} - \log E(YD) + \frac{1}{2}\sigma_{yd}^2}{\alpha}\right) &= \frac{1 - \text{prob}(Y_{LT} < YD)}{\text{prob}(Y_{LT} < YD)} \end{aligned}$$

Given the first order condition $\text{prob}(Y_{LT} < YD) = sl$ we can calculate $\log Y_{LT}$:

$$\log Y_{LT} = \log E(YD) - \frac{1}{2} \sigma_{yd}^2 - \alpha \cdot \frac{sl}{1 - sl}.$$

Using $Y_{LT} = LT \cdot \left(\frac{Y}{L}\right)^t$ we receive an expression for $\log LT$:

$$\log LT = \log E(YD) - \log\left(\frac{Y}{L}\right)^t - \frac{1}{2} \sigma_{yd}^2 - \alpha \cdot \log \frac{sl}{1 - sl}.$$

⁵⁶See also Lambert (1988) and Lambert, Mulkay (1987) for approximations with log logistic curves.

Variable list:

Y	: gross national product, real
L	: employment
UR	: unemployment rate
K	: net capital stock, real
DI	: disposable income
C	: Consumption real
I_g	: gross investment, real
i	: index for country (U. S. , UK: United Kingdom, F: France, I: Italy, NL: Netherlands, B: Belgium, W: World (all other countries))
$M1^i$: money (M1) of country i, nominal
X^i	: German exports into country i, real
M^i	: German imports from country i, real
TB^i	: trade balance account with country i, real
P	: price of Y
PC	: consumer price index
P_x	: German export price
P_m	: German import price
P^i	: GDP deflator of country i
E^i	: exchange rate (DM/unit of currency of country i)
Δpc^i	: inflationrate (change in logs of consumer price index of country i)
R, R_l	: interest rate, short term/long term
W	: wages per hour
d	: scrapping rate
t	: tariff rate (average yearly tariff rate for EEC-imports, 1960–68)
TAX	: value added tax rate
sl	: share of labour
sk	: share of capital
DUC	: degree of utilization of capital, Ifo-institut (Munich)
DUL	: degree of utilization of labour
$yc - l$: labour productivity
$yc - k$: capital productivity

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