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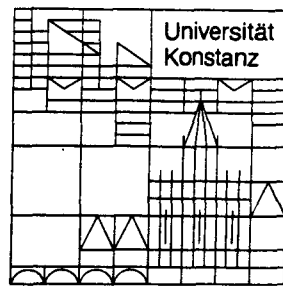
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**INTERNATIONAL TRANSMISSION OF ECONOMIC SHOCKS:  
THE CASE OF MIXED EXCHANGE RATES  
IN A THREE-COUNTRY WORLD**

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# International Transmission of Economic Shocks: The Case of Mixed Exchange Rates in a Three-Country World

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## Abstract

The international transmission of economic disturbances is analysed in a three-country world where two countries have no macroeconomic impact on a third country but are large enough to influence each other under a system of mixed exchange rates - a system that combines the fixed exchange rates (FERs) among two EC member countries (Germany and France) and the flexible exchange rates (FLERs) towards a third country, the rest of the world (USA). We find that a positive output demand shock originating in Germany or France has a positive effect on domestic output, but, due to a new third country effect, is likely to produce a *contractionary* impact on foreign output (negative transmission) while the total effect on the world economy is *expansionary*. Money supply shocks in either Germany or France have identical effects on the output of the two countries. The FLER component of the MER regime serves as an important tool for dampening the impact of US shocks on the output of the EC.

## 1 Introduction

Modern stochastic macroeconomic theory asserts that economic disturbances and policies are, in general, transmitted across countries, though the channels of transmission and the exact way in which economies respond to foreign shocks – whether the transmission is positive or negative – may depend on the type of exchange rate regime, the type of shock and the

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degree of capital mobility. Of particular concern has been the extent to which an economy is insulated from foreign disturbances under a flexible exchange rate (FLER) regime.

Long before the inception of the current system of managed exchange rates, a number of studies with open economy macroeconomic models suggested that transmission effects may be small in a FLER regime given the greater insulation properties of that regime. Friedman (1953), for example, showed that FLERs would suppress the international transmission of monetary shocks by eliminating the effects of changes in the foreign price level and allowing only the real effects to be transmitted across countries. Meade (1950), on the other hand, in his fixed price model with the assumption of perfect capital mobility, found that FLERs would completely insulate the domestic economy from foreign monetary disturbances. However, Mundell (1963), assuming perfect capital mobility, predicted that foreign monetary disturbances are negatively transmitted to the domestic economy.<sup>1</sup> Mundell (1968) also showed the possibility of a negative transmission of real shocks under a system of fixed exchange rates (FERs) with perfect capital mobility. Alternatively, Dornbusch (1976) and Mussa (1977) demonstrated that, with perfect capital mobility, the positive or negative transmission of monetary shocks depends upon the impact of foreign monetary shocks on exchange rate expectations, and thereby on the current exchange rate. Turnovsky and Kingston (1977), on the other hand, found a positive effect of an increase in foreign inflation on the domestic economy through a fall in the world real interest rate. Turnovsky (1981), in a rational expectations model, indicated that the domestic economy would be completely insulated from foreign price level disturbances. Marston (1984) investigated how a small country which has economic ties with a large country from an exchange rate union<sup>2</sup> and with another large country – the rest of the world – fares by joining the exchange rate union. The results indicate that domestic demand and monetary disturbances have identical effects on output in the small country, both in the FLER and FER regimes, if wages are fully indexed to the general price level. Short of full indexation, the case for the union (FER) is stronger, i.e. stability is higher if the monetary disturbances originate at home rather than abroad and it is weaker if domestic demand disturbances are important. The transmission of foreign monetary disturbances is higher in the FER than in the FLER regime. The transmission of foreign disturbances is also shown to be dependent on domestic and foreign wage and price behaviours. Argy et al.'s (1989) study on the choice of an appropriate exchange rate regime showed that the FLER regime performs well in protecting the domestic economy from real and monetary shocks. When choosing among various FER regimes, the small country is

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<sup>1</sup>The interested readers are further referred to Laursen and Metzler (1950), Branson and Rotemberg (1980), Cox (1980), Schmid (1982), Corden and Turnvosky (1983) and Argy and Salop (1983) for studies of negative transmission of foreign monetary disturbances.

<sup>2</sup>Marston (1984) defines the exchange rate union as "an arrangement in which member countries of the union maintain fixed exchange rates between member currencies, but with each country retaining its own central bank with control over its national monetary policy" (p.407).

better off pegging to a basket of currencies. A study by Läufer and Sundararajan (1992) – hereafter LS – addresses the question of whether stabilisation policies are more effective in a monetary union (FER regime) or in a FLER regime in a three-country world, where two small countries (a and b) are assumed to have no macroeconomic impact on a third country (c), but are large enough to influence each other. Their results indicate that while FERs insulate domestic output from *money supply* shocks originating at home (country a) and abroad (country b), FLERs are superior in dampening both the domestic impact and the international transmission of *output demand* shocks arising in these two countries. In addition, FLERs provide less output variation in the small countries a and b with respect to output shocks, price shocks and interest rate shocks originating in the large country, c. Therefore, unless economic disturbances are of pre-dominantly monetary nature and originate exclusively within the monetary union, LS's (1992) paper makes a very strong point for FLERs.

We observe that researchers have analysed the transmission of real and monetary shocks only in pure exchange rate regimes, either the FER or the FLER regime. The results suggest that the small transmission effects found in previous research for the OECD area depend largely on the existence of FLERs among the countries of this region. One is also led to suspect that the degree of interdependence and the transmission of economic shocks may be much larger among the countries forming the European Monetary System (EMS). The EMS region is, in fact, characterised by a very high degree of openness, pegged exchange rates and economic integration between the member countries. But the EMS is really a system of mixed exchange rates (MERs) – a system that combines FERs among EC member countries and FLERs towards the rest of the world, especially the USA – a feature that has not been analysed so far.

The above review clearly suggests that a study of a MER regime is conspicuously absent in the literature. In particular, because of the lacuna that exists in the literature concerning the international transmission of real and monetary shocks under MERs, the purpose of the present paper is to extend LS's (1992) analysis of a three-country world in order to examine the domestic impact and the international transmission of real and monetary shocks. Each of these disturbances has potential effects that depend on several factors like the degree of wage indexation, the type of exchange rate regime etc. The model used in this paper differs from other existing three-country models in two key aspects. Firstly, we replace the traditional (Marston) three-country assumption of a small open economy facing two large economies on which it has no impact. Instead, we assume that two countries have no macroeconomic impact on a third country, but are large enough to influence each other. Secondly, we also remove Marston's (1984) worrisome asymmetry between the degrees of wage indexation at home and abroad, as suggested by Kenen (1984) in his comments on Marston's model.<sup>3</sup>

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<sup>3</sup>See Kenen (1984), p. 441.

Section 2 presents our three-country model and uses the model to derive reduced form equations for output, producer prices of domestic output, consumer prices, exchange rates, reserve stocks, and nominal and real interest rates under MERs. In section 3, we present and discuss some simulation results that are designed to illustrate the qualitative and the quantitative importance of a variety of shocks for small countries under different degrees of wage indexation. In particular, we derive the possibility of a *contractionary* impact of positive foreign output demand shocks on domestic output (negative international transmission).

In our three country model, we discover an additional channel by which a negative international transmission of real shocks may occur. The additional channel is given by the FLERs between the two small countries and the rest of the world. A positive real shock in one of the two countries raises the interest rate in both small countries and causes an appreciation of the exchange rates with respect to the large third country. In both small countries, the appreciation will reduce exports to, and increase imports from country c, and thus reduce the demand for their output.

With the additional channel, a negative transmission from one (small) country to the other (small) country is now much more likely than in Mundell's two country world where a relatively high interest elasticity of investment demand is required in the country to which the real shock is transmitted.

## 2 The Model and its Solution

Consider a world consisting of three countries (a, b and c). For simplicity, we assume that countries a and b are identical (symmetric). That is, the structural parameters in the output demand and supply functions, and in the financial equations are the same for both countries. We further assume that countries a and b have no macroeconomic impact on country c but are large enough to influence each other. Thus the behaviour of country c is not modelled explicitly. Following LS's (1992) structure, the model of each country consists of three basic equations: aggregate demand and supply equations for the output produced in a country, and an equation describing equilibrium in financial behaviour. Perfect substitutability is assumed for the non-money assets of all three countries.

### 2.1 The Model

The model is set out as follows:

#### *Demand for Output*

$$Y_t^{ad} = \alpha_0 + \alpha_1 Y_t^{bd} + \alpha_2 Y_t^c - \alpha_3 r_t^a + \alpha_4 (e_t^{ab} + P_t^b - P_t^a) + \alpha_5 (e_t^{ac} + P_t^c - P_t^a) + u_t^{da}, \quad (1)$$

$$Y_t^{bd} = \alpha_0^* + \alpha_1^* Y_t^{ad} + \alpha_2^* Y_t^c - \alpha_3^* r_t^b + \alpha_4^* (-e_t^{ab} + P_t^a - P_t^b) + \alpha_5^* (e_t^{bc} + P_t^c - P_t^b) + u_t^{db}. \quad (2)$$

### Consumer Price Index

$$q_t^a = h_{11} P_t^a + h_{12} (e_t^{ab} + P_t^b) + h_{13} (e_t^{ac} + P_t^c), \quad (3)$$

$$q_t^b = h_{21} P_t^b + h_{22} (-e_t^{ab} + P_t^a) + h_{23} (e_t^{bc} + P_t^c). \quad (4)$$

### Supply of Output

$$Y_t^{as} = \theta (P_t^a - \omega_1 E_{t-1} P_t^a) - \theta b (q_t^a - E_{t-1} q_t^a) - \omega_2 E_{t-1} q_t^a + \theta_0, \quad (5)$$

$$W_t^{a'} = \omega_1 E_{t-1} P_t^a + \omega_1 \ln(1 - \theta') + C_1 E_{t-1} q_t^a, \quad (6)$$

$$W_t^a = W_t^{a'} + b (q_t^a - E_{t-1} q_t^a), \quad (7)$$

$$Y_t^{bs} = \theta^* (P_t^b - \omega_1^* E_{t-1} P_t^b) - \theta^* b^* (q_t^b - E_{t-1} q_t^b) - \omega_2^* E_{t-1} q_t^b + \theta_0^*, \quad (8)$$

$$W_t^{b'} = \omega_1^* E_{t-1} P_t^b + \omega_1^* \ln(1 - \theta^{*'}) + C_1^* E_{t-1} q_t^b, \quad (9)$$

$$W_t^b = W_t^{b'} + b^* (q_t^b - E_{t-1} q_t^b). \quad (10)$$

### Money Markets

$$M_t^{ad} - q_t^a = (P_t^a + Y_t^a - q_t^a) - \beta_1 i_t^a + \beta_0, \quad (11)$$

$$M_t^{bd} - q_t^b = (P_t^b + Y_t^b - q_t^b) - \beta_1^* i_t^b + \beta_0^*, \quad (12)$$

$$M_t^{as} = M_t^{ajs} + M_t^{ads} + u_t^{ma}, \quad (13)$$

$$M_t^{bs} = M_t^{bjs} + M_t^{bds} + u_t^{mb}. \quad (14)$$

### Equilibrium Conditions

$$Y_t^{ad} = Y_t^{as} = Y_t^a, \quad (15)$$

$$Y_t^{bd} = Y_t^{bs} = Y_t^b, \quad (16)$$

$$M_t^{ad} = M_t^{as}, \quad (17)$$

$$M_t^{bd} = M_t^{bs}. \quad (18)$$

### Interest Rate Arbitrage Conditions

$$i_t^a = i_t^c + (E_t e_{t+1}^{ac} - e_t^{ac}), \quad (19)$$

$$i_t^b = i_t^c + (E_t e_{t+1}^{bc} - e_t^{bc}), \quad (20)$$

$$r_t^a = i_t^a - (E_t q_{t+1}^a - q_t^a), \quad (21)$$

$$r_t^b = i_t^b - (E_t q_{t+1}^b - q_t^b). \quad (22)$$

### Triangular Arbitrage Condition



$$e_t^{ac} = e_t^{ab} + e_t^{bc}. \quad (23)$$

*MER Regime*

$$e_t^{ab} = \bar{k}^{ab}, \quad (24)$$

$$M_t^{ads} = \bar{M}^{ads}, \quad (25)$$

$$M_t^{bds} = \bar{M}^{bds}, \quad (26)$$

$$M_t^{ajfs} + (e_t^{ab} + M_t^{bjfs}) = \bar{f}^a. \quad (27)$$

*Rest of the World Sector*

$$Y_t^c = \bar{Y}^c + u_t^{yc}, \quad (28)$$

$$P_t^c = \bar{P}^c + u_t^{pc}, \quad (29)$$

$$i_t^c = \bar{i}^c + u_t^{ic}. \quad (30)$$

All variables are in logarithms, where superscripts d and s denote demand and supply and \* denotes the foreign country b.

$Y^j$	output in country $j$ , where $j = a, b, c$ .
$q^i$	consumer price index in country $i$ , where $i = a, b$ , expressed as the weighted average of domestic and foreign producer prices.
$W^{i'}$	contract wage in country $i$ .
$W^i$	nominal wage in country $i$ .
$M^{id}$	money demand in country $i$ .
$M^{is}$	money supply in country $i$ .
$M^{ifj}$	foreign component of the money supply in country $i$ .
$M^{ids}$	domestic component of the money supply in country $i$ .
$i^j$	nominal interest rate in country $j$ , where $j = a, b, c$ .
$r^i$	real interest rate in country $i$ .
$E_\tau q_{\tau+1}^i$	consumer price index of country $i$ for period $\tau + 1$ expected at $\tau$ ( $\tau = t - 1, t$ ).
$u^{di}$	output demand disturbance in country $i$ .
$e^{ij}$	exchange rate of currency $i$ per unit of currency $j$ ( $i, j = a, b, c$ ).
$P^j$	producer prices in country $j$ .
$E_{t-1} P_t^i$	producer prices in country $i$ for period $t$ expected at time $t - 1$ .
$u^{mi}$	money supply disturbance in country $i$ .
$E_t e_{t+1}^{ij}$	exchange rate of currency $i$ per unit of currency $j$ ( $i, j = a, b, c$ ) for period $t + 1$ expected at time $t$ .
$\bar{f}^a$	$2(\ln F^a - \ln 2)$ .
$F^a$	exogenous value of the sum of the reserve components

	of the national money supplies in countries <i>a</i> and <i>b</i> expressed in currency units of country <i>a</i> .
$\bar{k}^{ab}$	exogenous value of the exchange rate between countries <i>a</i> and <i>b</i> .
$\bar{M}^{ids}$	exogenous value of the domestic component of the money supply in country <i>i</i> .
$\bar{Y}^c$	exogenous value of output in country <i>c</i> .
$\bar{P}^c$	exogenous value of producer prices in country <i>c</i> .
$\bar{i}^c$	exogenous value of the rate of interest in country <i>c</i> .
$u_t^{yc}$	output disturbance in country <i>c</i> .
$u_t^{pc}$	price disturbance in country <i>c</i> .
$u_t^{ic}$	interest rate disturbance in country <i>c</i> .
<i>d</i>	sum of marginal propensities to save and to import in country <i>a</i> (or <i>b</i> ).
$\alpha_1, \alpha_2$	export elasticities of output demand in country <i>a</i> , that is the product of the income elasticities of the demand for country <i>a</i> 's output in the two foreign countries ( $h_b, h_c$ ) times the share of exports of country <i>a</i> to them as a fraction of total output of country <i>a</i> ( $\phi_b, \phi_c$ ) divided by <i>d</i> (See Marston (1984), pp. 434-37).
$\alpha_3$	real interest rate elasticity.
$\alpha_4, \alpha_5$	relative price elasticities of output demand in country <i>a</i> , that is the product of the price elasticities of imports and exports minus one ( $n_m + n_x - 1$ ) times the share of exports of country <i>a</i> to countries <i>b</i> and <i>c</i> as a fraction of total output of country <i>a</i> ( $\phi_b, \phi_c$ ) divided by <i>d</i> (See Marston (1984), pp. 434-37).
$h_{ik}$	expenditure weight in country <i>i</i> for country <i>k</i> 's good.
$\theta$	share of labour in the output supply.
<i>b</i>	indexation parameter.
$\delta$	elasticity of labour supply with respect to real wages.
$1 - \theta'$	exponent of labour in a Cobb-Douglas production function.
$\theta_0$	$(1 - \theta')\delta \ln(1 - \theta') / (\theta' \delta + 1)$ .
$\omega_1$	$1 / (\theta' \delta + 1)$ .
$\omega_2$	$\delta(1 - \theta') / (\theta' \delta + 1)$ .
$C_1$	$\theta' \delta / (\theta' \delta + 1)$ .
$\beta_1$	nominal interest rate elasticity of the money demand.

Equations (1)–(2) represent the demand for output in countries *a* and *b*. The demand is a function of foreign output, relative prices of foreign and domestic goods, and the real interest rate. In addition, each country is exposed to a real output demand disturbance ( $u_t^{di}$ ).<sup>4</sup>

<sup>4</sup>In equilibrium analysis a positive (negative) output demand disturbance is equivalent to a negative

Equations (5)–(8) explain the supply side of the economy. The supply behaviour is based on a labour contract lag of one period with partial or complete indexation of wages to current prices. Output is responsive to nominal wages relative to domestic prices, but the former is partially or fully indexed to the consumer price index, which is a weighted average of domestic and foreign producer prices. The supply functions (5) and (8) are derived from a Cobb-Douglas production function, the labour market equilibrium conditions (6) and (9) determining the contract wage, and the wage indexation equations (7) and (10). The contract wage, reflecting expectations at  $t - 1$ , is based on labour demand and supply.<sup>5</sup> The actual wage rate may differ from the contract wage rate if the indexation parameter is different from zero.<sup>6</sup> While only domestic prices affect output supply when there is no indexation, domestic as well as foreign producer prices influence output supply (via the consumer price index) if wages are partially or fully indexed.

Equations (11) to (14) are conventional money demand and supply equations. Real money demand is a positive function of real income and a negative function of the nominal interest rate. The behaviour of money supply in the MER regime is assumed to be a function of an endogenously determined reserve component and an exogenously given domestic component of the money supply. Each country is also exposed to a money supply disturbance ( $u_t^{mi}$ ).<sup>7</sup>

Equations (15) to (18) describe the product market and the money market equilibrium conditions. According to equations (19)–(20), the domestic interest rate is equal to the foreign interest rate plus the expected rate of depreciation of the domestic currency. The real interest rates in equations (21)–(22) are defined as the nominal interest rate minus the expected rate of inflation.

Equation (23) defines the exchange rate between  $a$  and  $c$  as the residual cross rate. Equations (24) to (27) describe the exogenous values of the exchange rate, the domestic component of the national money supplies and the reserve component of the money supply in the mixed exchange rate regime. The specification of equation (27) needs some explanation. It states that the sum of the reserve components of the national money supplies in countries  $a$  and  $b$ , expressed in the currency of country  $a$ , is equal to an exogenously given value  $\bar{f}^a$ . In order to derive this equation we start from a definition of  $F^a$ , the exogenous sum of the foreign components of the money supply in countries  $a$  and  $b$ , in non-logarithmic form:

$$F^a \stackrel{def}{=} \tilde{M}_t^{afs} + \tilde{e}_t^{ab} \tilde{M}_t^{bfs}.$$

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(positive) output supply disturbance.

<sup>5</sup>The supply of labour is assumed to be an increasing function of real wages.

<sup>6</sup>See Gray (1976), Fischer (1977), Sachs (1980), Flood and Marion (1982), Turnovsky (1983), Aizenman and Frenkel (1985,1986) and Devereux (1988) for studies of wage indexation behaviour.

<sup>7</sup>In equilibrium analysis a positive (negative) money supply disturbance is equivalent to a negative (positive) money demand disturbance.

$\tilde{M}$  and  $\tilde{e}$  are non-logarithmic equivalents of  $M$  and  $e$ . Given that the geometric mean is less than or equal to the arithmetic mean, we have:

$$(\tilde{M}^{afs})^{\frac{1}{2}}(\tilde{e}^{ab}\tilde{M}_t^{bfs})^{\frac{1}{2}} \leq \frac{\tilde{M}_t^{afs} + \tilde{e}_t^{ab}\tilde{M}_t^{bfs}}{2}.$$

The equality sign holds if  $\tilde{M}_t^{afs} = \tilde{e}_t^{ab}\tilde{M}_t^{bfs}$  which we assume to be the case in initial equilibrium. Therefore, we have:

$$2(\tilde{M}^{afs})^{\frac{1}{2}}(\tilde{e}^{ab}\tilde{M}_t^{bfs})^{\frac{1}{2}} = F^a.$$

Taking logarithm yields:

$$\ln 2 + \frac{1}{2}\ln\tilde{M}^{afs} + \frac{1}{2}(\ln\tilde{e}_t^{ab} + \ln\tilde{M}_t^{bfs}) = \ln F^a.$$

Rearranging the last expression we obtain equation (27).

Equations (28) to (30) explain that all the variables referring to country  $c$  are exogenously determined. They are expressed as a sum of a constant and a disturbance term.

Assuming that expectations follow long-run equilibrium values, we solve the equation system to obtain reduced forms for deviations from static long-run equilibrium values of seven endogenous variables:  $Y^a$ ,  $P^a$ ,  $q^a$ ,  $e^{ac}$ ,  $M^{afs}$ ,  $i^a$  and  $r^a$ . For convenience, the coefficients of the reduced forms are defined in the appendix.

## 2.2 Solutions for Real and Monetary Disturbances in Country $a$

The following equations show the deviations from long-run equilibrium values for seven endogenous variables in the MER regime:

$$Y_t^a - \bar{Y}^a = u_t^{yc} A_{71} - u_t^{ic} A_{72} + u_t^{pc} A_{73} + u_t^{da} A_{74} + u_t^{db} A_{75} + u_t^{ma} A_{76} + u_t^{mb} A_{77}, \quad (31)$$

$$P_t^a - \bar{P}^a = u_t^{yc} A_{78} - u_t^{ic} A_{79} + u_t^{pc} A_{80} + u_t^{da} A_{81} + u_t^{db} A_{82} + u_t^{ma} A_{83} + u_t^{mb} A_{84}, \quad (32)$$

$$q_t^a - \bar{q}^a = u_t^{yc} B_1 - u_t^{ic} B_2 + u_t^{pc} B_3 + u_t^{da} B_4 + u_t^{db} B_5 + u_t^{ma} B_6 + u_t^{mb} B_7, \quad (33)$$

$$e_t^{ac} - \bar{e}^{ac} = u_t^{yc} A_{50} - u_t^{ic} A_{51} + u_t^{pc} A_{52} + u_t^{da} A_{53} + u_t^{db} A_{54} + u_t^{ma} A_{55} + u_t^{mb} A_{56}, \quad (34)$$

$$M_t^{afs} - \bar{M}^{afs} = u_t^{yc} A_{43} - u_t^{ic} A_{44} + u_t^{pc} A_{45} + u_t^{da} A_{46} + u_t^{db} A_{47} + u_t^{ma} A_{48} + u_t^{mb} A_{49}, \quad (35)$$

$$i_t^a - \bar{i}^a = -u_t^{yc} A_{50} + u_t^{ic}(1 + A_{51}) - u_t^{pc} A_{52} - u_t^{da} A_{53} - u_t^{db} A_{54} - u_t^{ma} A_{55} - u_t^{mb} A_{56}, \quad (36)$$

$$\begin{aligned}
r_t^a - \bar{r}^a &= u_t^{yc}(B_1 - A_{50}) - u_t^{ic}(B_2 - 1 - A_{51}) + u_t^{pc}(B_3 - A_{52}) \\
&+ u_t^{da}(B_4 - A_{53}) + u_t^{db}(B_5 - A_{54}) \\
&+ u_t^{ma}(B_6 - A_{55}) + u_t^{mb}(B_7 - A_{56}).
\end{aligned} \tag{37}$$

### 3 Numerical Parameterization and Discussion of Results

Since the equations presented above are complex, signs are ambiguous and in order to analyse the quantitative importance of the international linkages, some numerical results are presented here. Germany, France and the United States are chosen as examples of countries a, b, and c respectively.<sup>8</sup> We treat Germany and France as mirror images of each other (symmetry assumption). In order to calibrate the model, we assume that country a's trade is bilaterally balanced with both that of countries b and c, thus differences in the coefficients of an output equation reflect only the role of elasticities and not the influence of trade imbalances. For simplicity, we also assume that trade and expenditure shares are equal ( $\phi_b = \phi_c = h_{12} = h_{13} = 0.15$ ). The trade shares are based on actual data of German exports in 1988 from the IMF's International Financial Statistics. Numerical values for behaviour parameters are based on our interpretation of the empirical literature. The parameter values chosen are specified in Table 1. For price elasticities, we used the estimates reported by Spencer's (1984) world trade model for industrial countries. Income elasticities were assumed to be equal to one. These values are consistent with the elasticities used by Ueda (1984), Sachs and McKibbin (1985) and Ishii et al. (1985). The chosen real and nominal interest rate elasticities correspond to the values in Sachs and McKibbin (1985), McKibbin and Sachs (1986), Dornbusch and Fischer (1981) and Argy et al. (1989). The expenditure shares in our calculation are consistent with the high values chosen for the domestic economy by McKibbin and Sachs (1986), Ishii et al. (1985) and Argy et al. (1989). The share of labour in output supply is assumed to be 0.67. This is close to the value reported by Devereux (1988). The parameter d is assumed to be equal to one. The indexation parameter is varied between zero and one with an increment of 0.01.<sup>9</sup>

Using the parameterisation just described, the model is simulated to study the effects of real and monetary disturbances originating at home and abroad for different degrees of indexation and various values of  $\alpha_5$ :

$$\alpha_5 = \begin{cases} \frac{0.335}{jj * jj * \sqrt{jj}} & jj = 1, \dots, 4 \\ 0 & jj = 5, \dots \end{cases} \tag{38}$$

<sup>8</sup>Throughout the discussion, for convenience, we alternatively use the terms, "the domestic economy", "the home country" and "Germany" to refer to country a.

<sup>9</sup>In the graphs of Figs. 1-4 the abscissa represents the degree of indexation in percentage terms.

Setting  $jj$  equal to 1 yields the  $\alpha_5$  value reported in Table 1 while higher values of  $jj$  yield  $\alpha_5$  values close to zero. For  $jj$  greater than 4, we constrain  $\alpha_5$  to zero. In Figures 1–4, the big dashed lines of the first graph stand for  $jj = 1$ , and the parameter values reported in Table 1; the small dashed lines of the second graph stand for  $jj = 2$ ; and so on. The last graph stands for  $\alpha_5 = 0$  ( $jj = 5$ ).

We assume that the stochastic shocks are of a transitory nature, they have a mean of zero and are serially uncorrelated.

Following the literature on the choice of an appropriate exchange rate regime, the analysis mainly concentrates on the transmission of real and monetary disturbances on output in the MER regime, though the response of other variables, e.g. prices and exchange rates is also discussed.

The effects are described by graphs for reaction coefficients (uday etc. in Figures 1–4). The first three letters of the labels for the reaction coefficients designate the random shock (cause), while the following letter(s) stand for the variable (in country a or the whole world) whose reaction is to be examined (effect). So, uday is the reaction of country a's output,  $y$ , to a random output demand shock in country b, udb. For reasons of symmetry, this is equivalent to the reaction of country b's output to a random output demand shock in country a. Hence, udb also serves to describe the effect of an output demand shock in country a on the output in country b.

### 3.1 Transmission of Output Demand Shocks

In this section, we analyse the effects of output demand shocks originating in countries a and b on the output of country a as well as on the world output.

#### 3.1.1 Output Demand Disturbances from country a

Firstly, we consider domestic output demand disturbances in country a (Germany) for the case of no wage indexation ( $b = 0$ ). A *positive* shock on country a's *demand* for output increases its real and nominal (equilibrium) output (see uday and udayn in Fig. 2), as well as its producer and consumer prices (see udap in Fig. 2 and udaq in Fig. 3). The rise in nominal output causes an increase in the domestic nominal and real interest rates (see udani and udari in Fig. 4). Due to the latter, there is an appreciation of the mark-dollar exchange rate (see udaac in Fig 3) while the mark-franc exchange rate is kept fixed at the initial level by interventions in the foreign exchange market. The appreciation of the mark-dollar exchange rate reduces the original increase in demand for German output without reversing it.<sup>10</sup>

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<sup>10</sup>A final decrease in equilibrium output would imply a fall in interest rates and thus would eliminate the reason for the appreciation: a contradiction.

In country a, where a uday curve has a negative slope, the output reaction falls as the degree of indexation increases. This is different in country b, where the corresponding uday curve has a positive slope: the output reaction rises with the degree of indexation. These slopes and differences will be explained in four steps by the movements of demand and supply curves in a price quantity diagram, with  $p$  on the ordinate and  $y$  on the abscissa (see Figure 5).

*Step 1:* Indexation affects only the output supply curve but in two different ways. *Firstly*, the higher the degree of indexation, the steeper the slope of the supply curve (slope effect). For a given rightward shift in the demand curve, the steeper the slope of the supply curve, the lower the increase in equilibrium output. By symmetry, changes in the slope of the supply curves are equal in the two countries, a and b. *Secondly*, the appreciation of the dollar exchange rate tends to lower the consumer price index and to increase real wages faced by workers. It therefore shifts the supply curve downwards (if indexation is not zero) and tends to increase the output (shift effect). The downward shift increases with the degree of indexation. It is easy to explain this shift. Indexation, meaning stabilisation of real wages, prevents real wages from both falling and rising. To the extent that the appreciation of the dollar exchange rate does not raise the real wage rate (faced by workers) due to indexation, the nominal wage rate must be falling with the appreciation of the dollar exchange rate. At the same time, the real wage rate with respect to the producers falls and the supply curve shifts downwards.

*Step 2:* The shifts in the supply curve, due to an appreciation of the change in exchange rates with country c, are equal in countries a and b. This follows from the assumed symmetry in the behaviour of countries a and b, and from the fact that – due to arbitrage – exchange rate changes cannot be different in these two countries.<sup>11</sup> Since the movements in the supply curve are equal in the two countries, differences in their output reaction curves cannot be explained by movements of the supply curve alone. Therefore, we turn our attention to demand curve shifts.

*Step 3:* The demand curve shifts are different in countries a and b, since the original demand shock in country a is transferred to the other country via the import demand function, with a marginal propensity to import smaller than one. The rise in interest rates and the appreciation of the exchange rate may even produce a net leftward shift in the demand curve of country b, even though the demand curve in country a has a net rightward shift.

*Step 4:* These observations can be combined to consistently interpret the slopes of the reaction curves for prices and output. As can be seen from Figure 5, in country a but not in country b, the slope and the shift effect of the supply curve are in conflict with each other. If

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<sup>11</sup>This is confirmed by the uday and udbac curves in Figure 3. The fact that these curves are symmetric means that the reaction of the exchange rate with country c (ac) does not depend on where the output demand shock originates. This implies that the reaction of the exchange rate with respect to country c (ac) is equal in the two countries.

### 3.1.2 Output Demand Disturbance from Country b

From the previous section we know that, for  $jj = 1$  and irrespective of the degree of wage indexation, a positive shock on output demand in country b (France) increases equilibrium output and prices in that country in the MER regime. Now, we observe from  $udby$ ,  $udbp$  and  $udbq$  in Figs. 2 and 3 that a positive *demand disturbance in France causes both output and prices in Germany to decrease in the MER regime*. One might expect the increased levels of French output and prices also to stimulate the demand for German commodities and thus tend to increase the output and prices in Germany. *How is it possible that an output demand shock coming from France, Germany's trading partner in the EMS, which has an expansionary effect on that country's output and prices produces a contractionary impact on Germany's output and prices?* Recall from the previous section, that in the MER regime, a positive output demand shock in France increases not only equilibrium output, but also the French equilibrium prices and interest rates. The increased level of interest rates in France is transmitted to Germany and induces pressure on both the mark-dollar and the franc-dollar exchange rates. They appreciate to the same degree. Thus, we observe three major forces (channels) affecting the output in Germany. Firstly, there is a positive stimulus on the German output demand arising from higher incomes in France via the income dependency of French imports from Germany. Secondly, there is a negative stimulus on the German output from higher interest rates. Finally, there is again a negative stimulus on the German output demand due to the appreciation of the mark-dollar exchange rate. These three factors may be distinguished as an income effect, an interest rate effect and an exchange rate effect. Mundell (1968) has drawn attention to the first two factors (effects) in two country models. The third factor is due to our three country framework. Exchange rate changes with a *third*

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country c, have the same effect on the real stock of money without changing relative prices, as have outflows of nominal money to country c in the pure FER regime. (A symmetric statement can be made with respect to money *inflows* to countries a and b from country c and deflation in a and b.) This is the reason why, with full indexation, the difference between the output effects of an output demand shock in the pure FER and the MER regime disappears.

A similar argument can be given for the case of money outflows from country a under the pure FER regime, in comparison with general inflation under full indexation in the pure FLER regime, if inflation and full indexation occurred in country a alone, i.e. if there were no inflation and indexation in countries b and c. Inflation in country a in the pure FLER regime would change country a's prices and the exchange rates not only with respect to country c but also with respect to country b. With full indexation this would eliminate any excess stock of real money in country a while leaving relative prices unchanged. (A symmetric statement can be made with respect to money *inflows* into country a and deflation with full indexation in country a *alone*.) Therefore, there would be no difference in the effect of country a's demand shock on its output between the pure FER and the pure FLER regimes. However, in our model we assume that the degree of indexation is the same for countries a and b (symmetry of behaviour in countries a and b). This violates the condition "full indexation in country a only" in the preceding argument. (As a matter of fact, this latter condition can be replaced by the condition "full indexation in countries a, b, and c", which, however, is violated as well, since our model does not assume indexation in country c.)



country cannot arise in two country models. Since the second factor *may* be sufficient to cause a negative transmission from France to Germany, the third factor is not necessary. But the working of the third factor increases the likelihood and the extent of a negative transmission. If the German output demand is not sensitive to interest rates, then, in Mundell's two country framework, a negative transmission would not be possible. However, in our three country framework it would still be possible since the negative exchange rate effect may dominate the positive income effect. As  $\alpha_5$  is lowered (jj increased), the third factor (exchange rate effect) loses its force and, consequently, the likelihood and degree of a negative transmission is lowered.

Consistent with a negative transmission, producer and consumer prices rise in France (see  $u_{dap}$  and  $u_{daq}$  in Figures 2 and 3) and fall in Germany (see  $u_{dbp}$  and  $u_{dbq}$  in Figures 2 and 3). The appreciation of the exchange rate (third factor) with respect to the US (country c) tends to lower consumer prices and thus mitigates the price rise in France (compare the numerical values of  $u_{daq}$  with those of  $u_{dap}$ ) and reinforces the decline of prices in Germany (compare the numerical values of  $u_{dbq}$  with those of  $u_{dbp}$ ).

In order to determine the parameter constellations under which a negative transmission occurs, we let  $\alpha_5$  approach zero in discrete steps. The following observations may be made. Firstly, for  $jj = 1$  (the parameter values reported in Table 1), the graph  $u_{dby}$  (in Figure 2) shows that a positive demand shock in country b is negatively transmitted to country a for all degrees of indexation. Secondly, as the value of  $\alpha_5$  is lowered, the  $u_{dby}$  curve shifts upwards. Thirdly, as the value of  $\alpha_5$  is lowered beyond a critical value, a negative transmission still occurs but not for all degrees of indexation. There exists a critical degree of indexation. Below this critical value, the transmission is negative and above this value, the transmission is positive. At the critical degree of indexation, country a's output is *completely insulated* from the real shock in country b. Fourthly, as  $\alpha_5$  decreases, the critical degree of indexation also decreases. Fifthly, as  $\alpha_5$  approaches zero, the response of demand for output in countries a and b to variations in the exchange rate with respect to country c is further reduced and is eventually eliminated. But even the limiting case ( $\alpha_5 = 0$ ) is not sufficient to have a positive transmission at all degrees of indexation. This limiting case corresponds to Mundell's two country analysis of the effects of domestic fiscal policy on foreign income in a FER regime.

### 3.1.3 Effects on the World Economy

Now, we turn to the impact of country b's demand shock ( $u_{db}$ ) on world<sup>13</sup> output ( $wy$ ) (see  $u_{dawy}$  in Figure 1).<sup>14</sup> Firstly, an increase in output demand in France leads to an increased output in that country such that, even if German output falls, as is the case for  $jj = 1$ , there

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<sup>13</sup>world=countries a and b together.

<sup>14</sup>For reasons of symmetry, this effect does not depend on the country (a or b) in which the shock originates. So, we may use a  $u_{dawy}$  curve to determine the effect of country b's output demand shocks.

we assume a dominance of the slope effect, the output reaction in country a will be smaller and the price reaction larger for higher degrees of indexation, and vice versa in country b. This assumption is consistent with the negative slope of the uday curves and the positive slope of the udby curves in Figure 2. It is also consistent with the positive slope of the udap curves and the negative slope of the udbp curves in Figure 2.

The reaction of producer prices dominates the reaction of nominal output. The reaction of nominal output rises only slightly in country a (see udayn in Fig. 2) while it changes more and falls in country b with the degree of indexation (see udbyn in Fig. 2). Therefore, the reaction of nominal world output (the sum of the values of output in countries a and b) declines with the degree of indexation (see udawyn in Fig. 1). Due to the assumption of perfect capital mobility, the reaction of interest rates, also declining with the degree of indexation, may be observed in either of the two countries a or b (see udani and udbni in Fig. 4).

As  $\alpha_5$  declines (jj increases), the (negative) sensitivity of country a's demand for output to an exchange rate appreciation with country c is reduced. Therefore, for all degrees of indexation, the net output reaction in country a is algebraically larger, than for  $jj = 1$ . Graphically, the position of the udaya curve shifts upwards as  $\alpha_5$  is reduced (Figure 2). Corresponding shifts are also observable for the udap and udayn curves (Figure 2). Since lower  $\alpha_5$  values imply an upward shift in the interest rate reaction curves (see udani and udari in Figure 4), there must be a downward shift in the exchange rate reaction curves (see udaac in Figure 3). A downward shift in the consumer price index reaction curves udaq (Figure 3) is also consistent with this result.

A comparison of the results for our MER regime with the results of LS (1992) for the pure FER and FLER regimes suggests various patterns. Firstly, for  $b = 0$ , while output in country a increases more in the pure FER regime than in the MER regime, the increase is lower with pure FLERs than with MERs. Secondly, for partial indexation ( $0 < b < 1$ ), FLERs are still effective in reducing the variability of output but the difference in output variability between the regimes becomes lower as the degree of indexation increases. Finally, for full indexation ( $b = 1$ ), the increase in output in country a is identical in both the pure FER and the MER regime, while a difference remains between the output change in these and the pure FLER regimes.<sup>12</sup>

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<sup>12</sup>In LS (1992), these differences in effectiveness with full indexation are explained by a modelling asymmetry: full indexation both in countries a and b but not in c.

A full explanation is not short. Outflows of nominal money from countries a and b to the large country c eliminate excess supplies of real money in the pure FER regime without any relative price changes. In the MER regime, such outflows are blocked by flexible exchange rates with respect to country c. The difference between the output effects of output demand shocks in these two regimes is due to this *monetary* asymmetry. In the case of full indexation, this asymmetry disappears. General inflation in countries a and b, i.e. price increases in countries a and b which are equal in size to a depreciation of the exchange rate with respect to

is an increase in world output. In other words, a *positive demand shock* in one of the two countries (a or b) produces an *expansionary* effect on the world economy even if there is a *contractionary* impact on the other country (negative transmission). Secondly, the higher the degree of indexation, the higher the increase in world output. The positive slope of the udawy curves in Figure 1 may be explained as follows. A positive demand shock causes a rise in (world) interest rates and causes the exchange rate with respect to country c to appreciate in countries a and b. This shifts the supply curves in these countries downwards. Increasing the indexation parameter  $b$  has two effects. Firstly, it steepens the supply curve (slope effect) which tends to reduce the change in equilibrium output. Secondly, it increases the downward shift in the supply curve, due to the appreciation (shift effect), which tends to increase the change in equilibrium output. The opposite slope effects in the two countries (see Figure 5) tend to neutralise each other with respect to world output and cause the increasing shift effects to dominate.

## 3.2 Transmission of Money Supply Shocks

### 3.2.1 Effects on Countries a and b

It is clear from  $u_{maw}$ ,  $u_{may}$  and so on in Figures 1 etc. that the effects of money supply shocks on output and other endogenous variables in either country (a or b) do not depend on whether the monetary shocks stem from country a or b. Foreign reserves are an exception. Both countries a and b cannot increase their foreign reserves at the same time. The country in which an expansionary money supply shock occurs will lose reserves and the other country will gain them.<sup>15</sup> An increase in the supply of money in Germany (France) puts pressure on the mark-franc exchange rate, but the intervention in the exchange market, which keeps the exchange rate fixed, results in an offsetting reserve outflow to France (Germany), shown by  $u_{mars}$  and  $u_{mbrs}$  in Figure 3. Irrespective of the degree of indexation and of  $jj$ , a one per cent increase in the money stock of Germany (France) results in an offsetting reserve outflow to France (Germany) which is equal to 0.5 per cent of the French (German) money stock. The monetary shock lowers interest rates in both countries (a and b) and causes a depreciation with respect to country c. Both effects stimulate the demand for output. The depreciation effect on the demand for output declines and eventually disappears as  $\alpha_5$  approaches zero. This explains the positions of the  $u_{may}$ ,  $u_{mby}$ , and  $u_{maw}$  curves in Figures 1 and 2 for alternative values of  $jj$ . If  $\alpha_5$  is reduced to zero ( $jj=5$ ), the depreciation effect on output demand vanishes but equilibrium output still expands, due to a lower interest rate as long as the indexation is below 100 percent. With full indexation, there is no change in output. This may be explained by the behaviour of output supply.

The output supply curve exhibits shift and slope effects. An increase in the indexation

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<sup>15</sup>This is an equalising difference.

parameter  $b$  steepens the supply curve (slope effect). The depreciation with respect to country  $c$  causes an upward shift in the supply curve (if indexation is not zero), a shift which increases with the degree of indexation. An upward shift in the supply curve of country  $a$  ( $b$ ) is also caused by an increase of producer prices in country  $b$  ( $a$ ). These slope and shift effects of the supply curve reduce the output expansion more and more as the degree of indexation increases. With full indexation, real output does not respond anymore to the monetary impulse, regardless of the size of  $\alpha_5$ .<sup>16</sup>

Obviously, we observe upward shifts in both demand and supply curves. If (for less than full indexation) the demand curve shifts were not larger, we would not observe an increase in equilibrium output. Given the upward shifts in the supply curve, a rising output must be accompanied by an increasing producer price index ( $p$ ). Therefore, if output reactions are stronger, due to larger  $\alpha_5$  values, the reaction of producer prices ( $p$ ) must be larger as well. This explains the position of the reaction curves for *nominal* output and producer prices for alternative values of  $jj$ .

The lower the nominal output reaction, the larger the fall in interest rates and, therefore, the larger the depreciation of the exchange rate with respect to country  $c$ . This explains the positions of the  $umani$ ,  $umbni$ ,  $umari$ ,  $umbri$ ,  $umaac$ , and  $umbac$  curves for alternative values of  $jj$  (see Figures 2, 3, and 4).

Since the slope and shift effects of the output supply curve lower the output reaction to a monetary stimulus as the degree of indexation rises (see the negative slopes of the  $umay$ ,  $umby$ , and  $umawy$  curves), they must, at the same time, increase the producer price reaction as the degree of indexation rises. Therefore, the slope of the producer price reaction curves is opposite to the slope of the output reaction curves.<sup>17</sup> Since the change in the reaction of producer prices is also stronger than that of real output, the reaction of nominal output rises with the degree of indexation.

The slopes of the interest rate and exchange rate reaction curves may be explained by the slopes of the nominal output reaction curves. If nominal output reactions rise with the degree of indexation, then the demand for money increases with the degree of indexation. This causes the interest rates to fall less and the exchange rate to depreciate less as the degree of indexation increases.

The reaction of the exchange rate with respect to country  $c$  is responsible for the differences between the reaction of producer (see  $umap$ ,  $umbp$  in Figure 2) and consumer prices (see  $umaq$ ,  $umbq$  in Figure 3).

A comparison of our results for MERs with LS' (1992) results for pure FERs and pure FLERs suggests that while the FER regime offers complete insulation of output from mone-

<sup>16</sup>Prices in  $a$  and  $b$  and the exchange rate with respect to  $c$  rise to the same extent. The movements of the supply curve produce results as if the supply curve were fixed but perpendicular.

<sup>17</sup>See the  $umap$  and  $umbp$  curves in Figure 2.

tary shocks in country a or b for all degrees of indexation, the MER regime is more effective than the FLER regime in reducing the variability of output. The difference in output reaction between the pure FER and the MER regime becomes smaller as the degree of indexation rises and disappears for full indexation, while a difference in output reaction still remains between the pure MER and the FLER regime even if indexation is full.<sup>18</sup>

### 3.2.2 Effects on the World Economy

We now consider the effect of monetary shocks in country a on the world economy (see *umaw* in Figure 1). Four results merit our attention. Firstly, the monetary shock in country a leads to an increase, not only in the output of that country, but also in world output. Secondly, as  $\alpha_5$  is lowered, the world output reaction declines but remains positive even if  $\alpha_5 = 0$ , as long as indexation is not full. Thirdly, the higher the degree of indexation, the lower the increase in world equilibrium output. Finally, the world output is *completely insulated* from monetary shocks if wages are fully indexed to the consumer price index.

### 3.3 Disturbances from Country c

Since the behaviour of the US is not modelled explicitly here, shocks from the US are grouped as output shocks, price shocks and interest rate shocks rather than as what we have so far called real and monetary shocks.

Regardless of the degree of wage indexation and of  $jj$ , a rise in *US output* increases output and prices in Germany (France) (see *uycy*, *uycp*, and *uycq* in Figure 2 and 3). The ensuing increase in interest rates (see *uycni* and *uycri* in Figure 4) leads to an appreciation of the mark-dollar (franc-dollar) exchange rate (see *uycac* in Figure 3). This appreciation reduces the initial increase in output demand caused by the positive output shock in country c. As the sensitivity of output demand to exchange rate changes is reduced if  $\alpha_5$  is lowered ( $jj$  is increased), the reaction curves of output, prices and interest rates (*uycy*, *uycp*, *uycni*, *uycri*) move upwards. Larger interest rate reactions cause in turn larger exchange rate appreciations. This explains the downward shifts in the exchange rate reaction curves (see *uycac* in Figure 3).

The *slope* of the output reaction curves can be explained by the output supply shifts which increase with the degree of indexation. We have already stated that the demand impulse from country c causes an appreciation and this shifts the output supply curve downwards (provided  $b > 0$ ) and contributes to a higher equilibrium output. The downward shift in the supply curve increases with the degree of indexation. Thus, the output reaction increases with the degree of indexation. The slope of the supply curve also increases with the degree of indexation. However, the slope change is increasingly overruled by the shifts in the

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<sup>18</sup>The explanation given earlier in the case of demand for output shocks carries over to the present case.

supply curve.<sup>19</sup> The downward shift in the supply curve also tends to lower producer prices, which explains the negative slope of the price reaction curve. The reaction of *nominal* output declines with the degree of indexation (see *uycyn* in Figure 2). This explains the negative slope of the interest rate reaction curve. The negative exchange rate reactions are numerically much stronger than the positive producer price reactions, which are consistent with the observed decline in consumer prices. The decline in the positive producer price reaction with the degree of indexation is stronger than the decline in the negative exchange rate reaction. This implies an increase of the negative consumer price reaction (negative slope of *uycq*).

Higher *US prices* have two conflicting influences on the output demand in Germany and France. Firstly, they tend to raise the demand for output in Germany and France through the international relative price mechanism, depending on the size of  $\alpha_5$ . Secondly, transitory US price shocks directly increase consumer prices in Germany and France and thus create a deflationary expectation. This shifts real interest rates up and causes output demand to fall in Germany and France. The initial parameter constellation chosen ( $jj=1$ ), implies a dominance of the first influence, i. e. the one working through the international relative price mechanism. As  $\alpha_5$  is lowered, the influence of international relative price changes on output demand is weakened. This lowers the position of the output reaction curves (see *upcy* in Figure 2). If  $\alpha_5$  is zero, only the rise in real interest rates will determine the shift in output demand and the output reaction becomes definitely negative. Obviously, there exists a critical value of  $\alpha_5$ . Above this critical value, international relative price changes dominate and below this critical value, the shift in real interest rates dominates. The critical value of  $\alpha_5$  rises with the degree of indexation.

The *slope* of the reaction curves for output may be explained as follows: With indexed wages, the price shock from the US will cause an upward shift in the output supply curve. This lowers any increase in equilibrium output and pushes up price rises caused by an increase in the demand for output. The extent of this shift in the supply of output increases with the degree of indexation. As a result, the slopes of the output and price reaction curves are negative and positive respectively. The upward shift in the supply of output also explains the rise in the critical value of  $\alpha_5$  mentioned in the preceding paragraph.

The reaction of the producer price level may be positive or negative (see *upcp* in Figure 2). It is negative, if the demand reducing effect of the initial increase in real interest rates dominates not only the demand increasing effect of the international relative price change but also the price increasing shift in the supply curve. There is a critical level of indexation at which a negative price reaction turns positive. This is due to the increase in the upward

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<sup>19</sup>Earlier, in connection with demand for output shocks in country a, we have assumed a dominance of the slope effect over the shift effect on the output supply. There, however, the primary impulse did not come from country c but from country a. This difference prevents any logical contradiction.

shift of the supply curve caused by an increase in the degree of indexation.

We have already observed that a transitory increase in US prices immediately causes the real rate of interest (in countries a and b) to rise without any prior changes in the nominal interest rate. This is the reason for a persistently larger reaction of the real interest rate as compared to the nominal interest rate. Finally, it explains why the real interest rate never declines, while the nominal rate may decline as a result of a positive US price shock at lower values of  $\alpha_5$  and lower degrees of indexation.

The reaction curves for the nominal value of output and the nominal and real interest rates have positive slopes. The position and slope of a nominal interest rate reaction curve explain the position and slope of the corresponding exchange rate reaction curve.

For real output, producer prices, nominal interest rates and exchange rates with country c, there exist, respectively, different critical degrees of indexation where the two countries, a and b, are *completely insulated* from US price shocks. These different critical degrees of indexation also react differently to changes in the parameter  $\alpha_5$ .

A positive shock in the *US nominal interest rate* has effects which are largely identical to those of a positive shock in the US prices. Only the reaction curves for exchange rates are different. A positive shock in the nominal interest rate of country c implies a *primary* depreciation of the exchange rates in countries a and b with respect to country c and therefore a primary rise in the real interest rate of countries a and b. These initial changes stimulate or reduce the output demand and shift the output supply curve upwards to the same extent as a US price shock would do if it were equal in size to the primary change in exchange rates. Thus, a shock on US nominal interest rates is equivalent to a US price shock as far as the reactions of output, prices, nominal and real interest rates in countries a and b are concerned. The critical difference between the two cases arises in the reaction of the exchange rates. But this is an equalising difference which establishes the equivalence in all other respects.<sup>20</sup>

Given the equivalence between US price and interest rate shocks, all explanations carry over from one case to the other.

## 4 Concluding Remarks

We have examined the international transmission of economic shocks in a three-country world in which two countries (Germany and France) have no macroeconomic impact on a third country (the US) but are large enough to influence each other in a MER regime.<sup>21</sup> We

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<sup>20</sup>The total (primary and secondary) exchange rate reaction for an interest rate shock in country c is equal to the exchange rate reaction for a price shock in country c plus 1. The 1 represents the primary depreciation mentioned above.

<sup>21</sup>Apart from the results reported in this paper, a sensitivity test was also performed for the following two assumptions. (i) Country a's trade is evenly balanced so that the country's trade shares, income and price elasticities are all equal with respect to countries b and c. (ii) Trade is still balanced so that  $h_{12} = h_{13}$  and

have drawn insights from a theoretical three-country model and have given some quantitative evidence on the consequences for small countries of a variety of shocks under different degrees of indexation. Firstly, as far as domestic demand disturbances are concerned, an increase in output demand in Germany increases the output of that country. However, the increase in output decreases as the degree of indexation increases. Secondly, a positive output demand shock in France (Germany) may produce a *contractionary* effect on Germany's (France's) output (*negative transmission*). Thirdly, the increase in output demand in France (Germany) must have an *expansionary* effect on world output, even when it produces a *contractionary* effect on the German (French) output. Fourthly, positive money supply shocks from countries a and b increase output in both countries (world output) but lesser and lesser as the degree of indexation increases. With full indexation, the MER regime *completely insulates* the German, French and world output from monetary shocks. Fifthly, with respect to shocks coming from country c (the US), the FLER part of the MER regime serves as an important tool in reducing the variability of output in both Germany and France. Sixthly, divergent critical degrees of indexation exist where Germany's (France's) output is *completely insulated* from the real shocks coming from France (Germany) and the interest rate and price shocks coming from the large country, the US. This suggests that a *unique* critical degree of indexation, which would provide complete insulation from all these shocks, does not exist. Seventhly, as an important contributing factor to the possibility of a negative transmission of real shocks from country b to a (or a to b), we have identified the exchange rates with respect to country c. This is a determinant which cannot occur in two country models. Finally, while Mundell observed a negative transmission for a sufficiently high interest elasticity of output demand, our new factor may be sufficient to produce a negative transmission, even if the interest elasticity of the demand for output is quite low, if not zero.<sup>22</sup>

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$\alpha_1 = \alpha_2$  but the price elasticities are higher in country b than in country c. The results, however, do not change our main conclusions.

<sup>22</sup>In order to determine, for  $\alpha_5 = 0$ , at what parameter constellations the negative transmission due to Mundell's factor turns into a uniformly positive transmission, we let  $\alpha_3$  approach zero in the same way as  $\alpha_5$  in equation (38). The results show that the impact of country b's demand shock on country a's output is uniformly positive for  $jj \geq 2$ .



## Appendix

### Definition of Coefficients used in the Derivation of Reduced Forms

$$\begin{aligned}
 I &= \alpha_1 \alpha_3^* h_{22} - \alpha_1 \alpha_4^* + \alpha_3 h_{11} + \alpha_4 + \alpha_5 \\
 J &= \alpha_1 \alpha_3^* h_{21} + \alpha_1 \alpha_4^* + \alpha_1 \alpha_5^* + \alpha_3 h_{12} - \alpha_4 \\
 K &= 1 - \alpha_1 \alpha_1^* \\
 L &= \theta(1 - bh_{11}) \\
 M &= \alpha_1 \alpha_5^* - \alpha_1 \alpha_3^* h_{23} + \alpha_5 - \alpha_3 h_{13} \\
 N &= (\theta bh_{12}/L) - [(JL + I\theta bh_{12})/L(KL + I)] \\
 O &= [(L\alpha_3 - L\alpha_3 h_{13} + L\alpha_5 - I\theta bh_{13})/L(KL + I)] + \theta bh_{13}/L \\
 P &= L\alpha_1 \alpha_3^* - L\alpha_1 \alpha_3^* h_{23} + L\alpha_1 \alpha_5^*/L(KL + I) \\
 Q &= (L\alpha_1 \alpha_2^* + L\alpha_2)/L(KL + I) \\
 R &= (L\alpha_1 \alpha_3^* + L\alpha_3)/L(KL + I) \\
 S &= [(ML - I\theta bh_{13})/L(KL + I)] + \theta bh_{13}/L \\
 T &= L/L(KL + I) \\
 U &= L\alpha_1/L(KL + I) \\
 V &= (O + NP)/(1 - NN) \\
 W &= (P + NO)/(1 - NN) \\
 X &= (Q + NQ)/(1 - NN) \\
 Y &= (R + NR)/(1 - NN) \\
 Z &= (S + NS)/(1 - NN) \\
 Z_1 &= (T + NU)/(1 - NN) \\
 Z_2 &= (U + NT)/(1 - NN) \\
 TR &= L/(KL + I) \\
 UR &= L\alpha_1/(KL + I) \\
 A_1 &= (JL + I\theta bh_{12})/(KL + I) \\
 A_2 &= (L\alpha_3 - L\alpha_3 h_{13} + L\alpha_5 - I\theta bh_{13})/(KL + I) \\
 A_3 &= L\alpha_1 \alpha_3^* - L\alpha_1 \alpha_3^* h_{23} + L\alpha_1 \alpha_5^*/(KL + I) \\
 A_4 &= (L\alpha_1 \alpha_2^* + L\alpha_2)/(KL + I) \\
 A_5 &= (L\alpha_1 \alpha_3^* + L\alpha_3)/(KL + I) \\
 A_6 &= (ML - I\theta bh_{13})/(KL + I) \\
 A_7 &= V + A_2 - A_1 W + \beta_1 \\
 A_8 &= W + A_3 - A_1 V
 \end{aligned}$$

$$\begin{aligned}
A_9 &= X + A_4 - A_1 X \\
A_{10} &= Y + A_5 - A_1 Y + \beta_1 \\
A_{11} &= Z + A_6 - A_1 Z \\
A_{12} &= Z_1 + TR - A_1 Z_2 \\
A_{13} &= Z_2 + UR - A_1 Z_1 \\
A_{14} &= A_7(1 + A_7) \\
A_{15} &= (A_8 + A_7) - A_8(1 + A_7) \\
A_{16} &= A_9 - A_9(1 + A_7) \\
A_{17} &= A_{10} - A_{10}(1 + A_7) \\
A_{18} &= A_{11} - A_{11}(1 + A_7) \\
A_{19} &= A_{12} - A_{12}(1 + A_7) \\
A_{20} &= A_{13} - A_{13}(1 + A_7) \\
A_{21} &= A_{14}A_{14} \\
A_{22} &= A_{21} - A_{15}A_{15} \\
A_{23} &= A_{15}A_{16} + A_{14}A_{16} \\
A_{24} &= A_{15}A_{17} + A_{14}A_{17} \\
A_{25} &= A_{15}A_{18} + A_{14}A_{18} \\
A_{26} &= A_{15}A_{20} + A_{14}A_{19} \\
A_{27} &= A_{15}A_{19} + A_{14}A_{20} \\
A_{28} &= A_7A_{14} \\
A_{29} &= A_7A_{15} \\
A_{30} &= A_7 + A_8 \\
A_{31} &= 1 + A_7 \\
A_{32} &= A_{31}A_{22} + A_{30}A_{28} \\
A_{33} &= A_{30}A_{23} + A_9A_{22} \\
A_{34} &= A_{30}A_{24} + A_{10}A_{22} \\
A_{35} &= A_{30}A_{25} + A_{11}A_{22} \\
A_{36} &= A_{30}A_{27} + A_{12}A_{22} \\
A_{37} &= A_{30}A_{26} + A_{13}A_{22} \\
A_{38} &= A_{30}A_{29} - A_{22} \\
A_{39} &= A_{30}A_{28} \\
A_{40} &= A_{30}A_{29} + A_7A_{22}
\end{aligned}$$

$$\begin{aligned}
A_{41} &= A_{32}A_{32} \\
A_{42} &= A_{41} - A_{40}A_{40} \\
A_{43} &= (A_{32}A_{33} - A_{40}A_{33})/A_{42} \\
A_{44} &= (A_{32}A_{34} - A_{40}A_{34})/A_{42} \\
A_{45} &= (A_{32}A_{35} - A_{40}A_{35})/A_{42} \\
A_{46} &= (A_{32}A_{36} - A_{40}A_{37})/A_{42} \\
A_{47} &= (A_{32}A_{37} - A_{40}A_{36})/A_{42} \\
A_{48} &= (A_{32}A_{38} - A_{40}A_{39})/A_{42} \\
A_{49} &= (A_{32}A_{39} - A_{40}A_{38})/A_{42} \\
A_{50} &= (A_{23} - A_{29}A_{43} - A_{28}A_{43})/A_{22} \\
A_{51} &= (A_{24} - A_{29}A_{44} - A_{28}A_{44})/A_{22} \\
A_{52} &= (A_{25} - A_{29}A_{45} - A_{28}A_{45})/A_{22} \\
A_{53} &= (A_{26} - A_{29}A_{46} - A_{28}A_{47})/A_{22} \\
A_{54} &= (A_{27} - A_{29}A_{47} - A_{28}A_{46})/A_{22} \\
A_{55} &= (A_{28} - A_{29}A_{48} - A_{28}A_{49})/A_{22} \\
A_{56} &= (A_{29} - A_{29}A_{49} - A_{28}A_{48})/A_{22} \\
A_{57} &= A_2 - A_1W \\
A_{58} &= A_3 - A_1V \\
A_{59} &= A_4 - A_1X \\
A_{60} &= A_5 - A_1Y \\
A_{61} &= A_6 - A_1Z \\
A_{62} &= TR - A_1Z_2 \\
A_{63} &= UR - A_1Z_1 \\
A_{71} &= A_{59} + A_{57}A_{50} + A_{58}A_{50} \\
A_{72} &= A_{60} + A_{57}A_{51} + A_{58}A_{51} \\
A_{73} &= A_{61} + A_{57}A_{52} + A_{58}A_{52} \\
A_{74} &= A_{62} + A_{57}A_{53} + A_{58}A_{54} \\
A_{75} &= A_{63} + A_{57}A_{54} + A_{58}A_{53} \\
A_{76} &= A_{57}A_{55} + A_{58}A_{56} \\
A_{77} &= A_{57}A_{56} + A_{58}A_{55} \\
A_{78} &= X + VA_{50} + WA_{50} \\
A_{79} &= Y + VA_{51} + WA_{51}
\end{aligned}$$

$$\begin{aligned}
A_{80} &= Z + VA_{52} + WA_{52} \\
A_{81} &= Z_1 + VA_{53} + WA_{54} \\
A_{82} &= Z_2 + VA_{54} + WA_{53} \\
A_{83} &= VA_{55} + WA_{56} \\
A_{84} &= VA_{56} + WA_{55} \\
B_1 &= h_{11}A_{78} + h_{12}A_{78} + h_{13}A_{50} \\
B_2 &= h_{11}A_{79} + h_{12}A_{79} + h_{13}A_{51} \\
B_3 &= h_{11}A_{80} + h_{12}A_{80} + h_{13}(A_{52} + 1) \\
B_4 &= h_{11}A_{81} + h_{12}A_{82} + h_{13}A_{53} \\
B_5 &= h_{11}A_{82} + h_{12}A_{81} + h_{13}A_{54} \\
B_6 &= h_{11}A_{83} + h_{12}A_{84} + h_{13}A_{55} \\
B_7 &= h_{11}A_{84} + h_{12}A_{83} + h_{13}A_{56}
\end{aligned}$$

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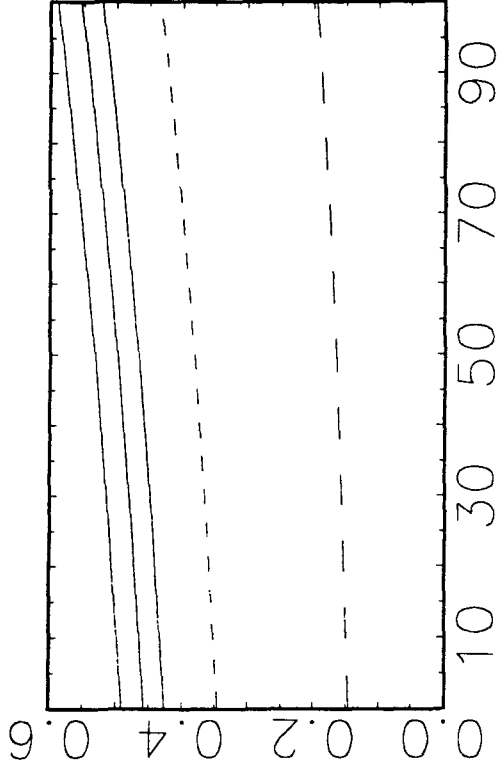
Table 1:  
Parameter Values

$h_b = 1.00$	$n_{xb} = 1.15$	$n_{xc} = 1.56$	$n_{mb} = 1.41$
$h_c = 1.00$	$n_{mc} = 1.67$	$h_{11} = 0.70$	$h_{12} = 0.15$
$h_{13} = 0.15$	$\theta = 0.67$	$\alpha_1 = 0.15$	$\alpha_2 = 0.15$
$\alpha_3 = 0.10$	$\alpha_4 = 0.234$	$\alpha_5 = 0.335$	$\beta_1 = 0.20$

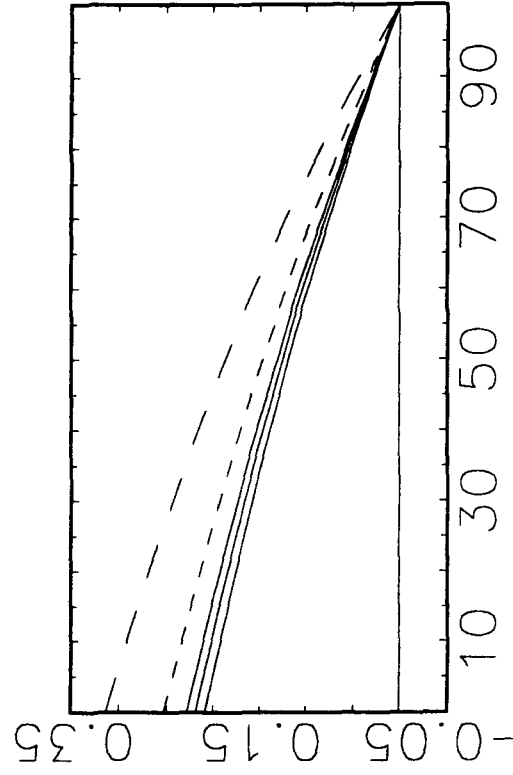


Figure 1

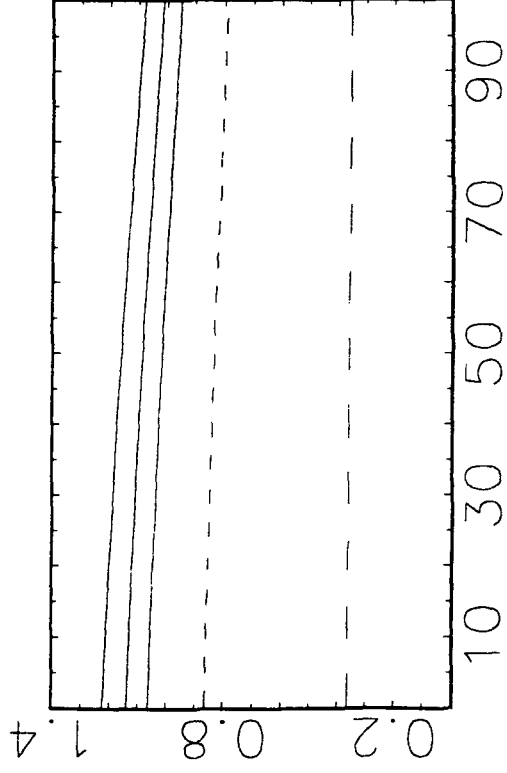
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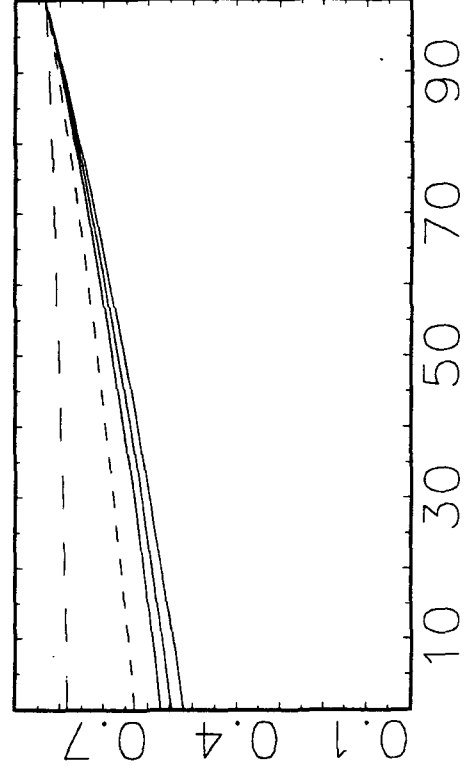


Figure 2

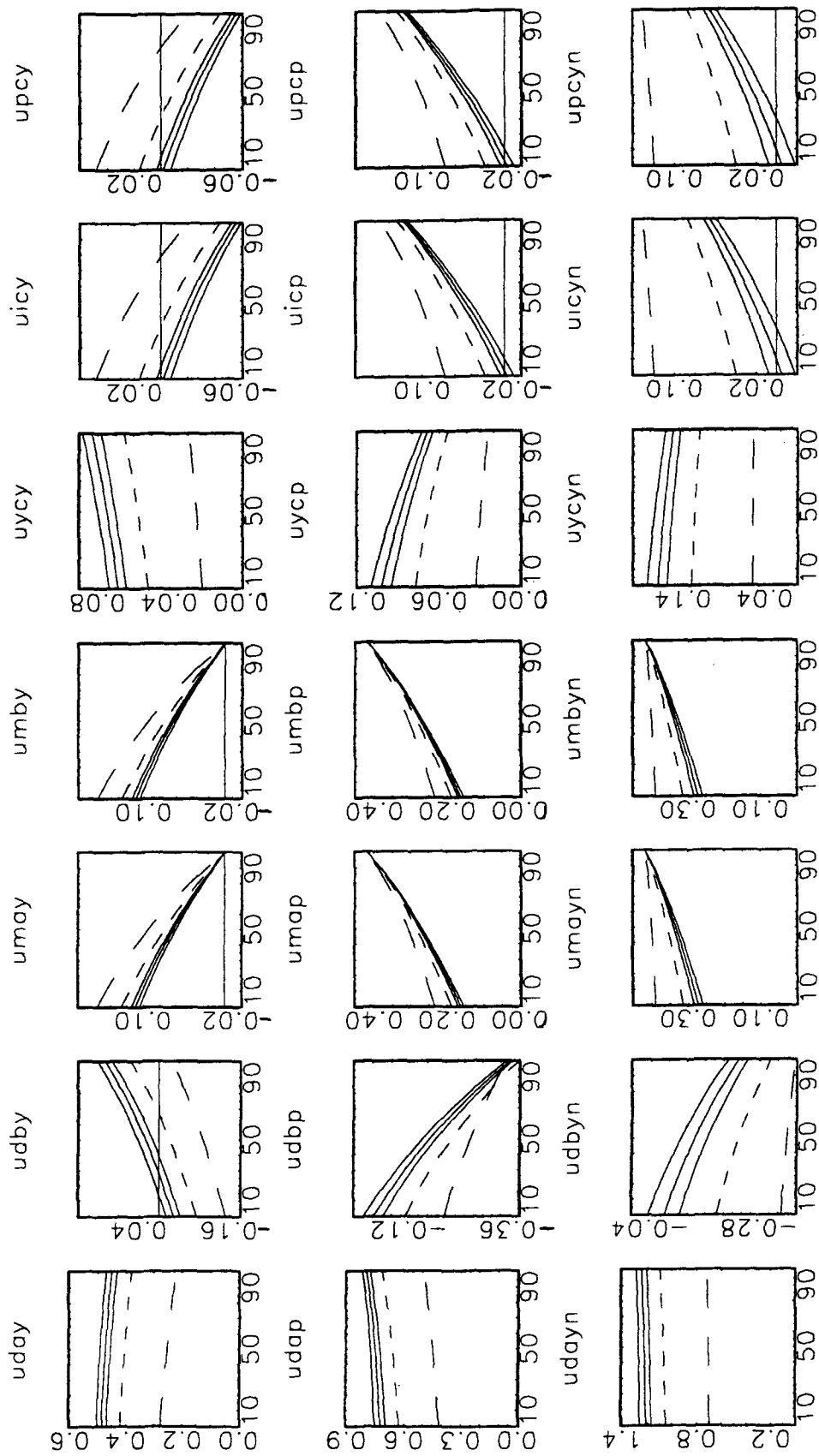


Figure 3

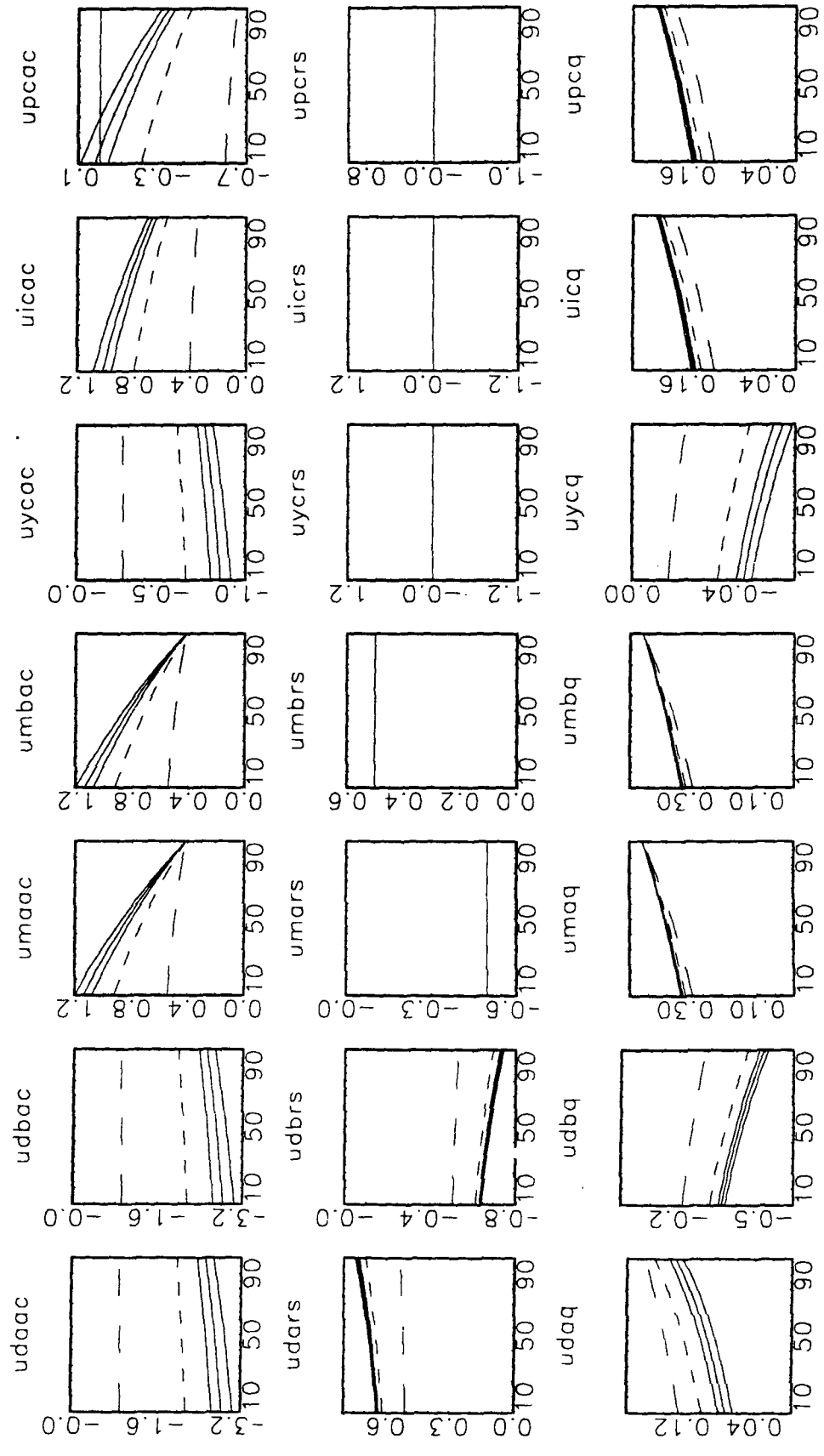


Figure 4

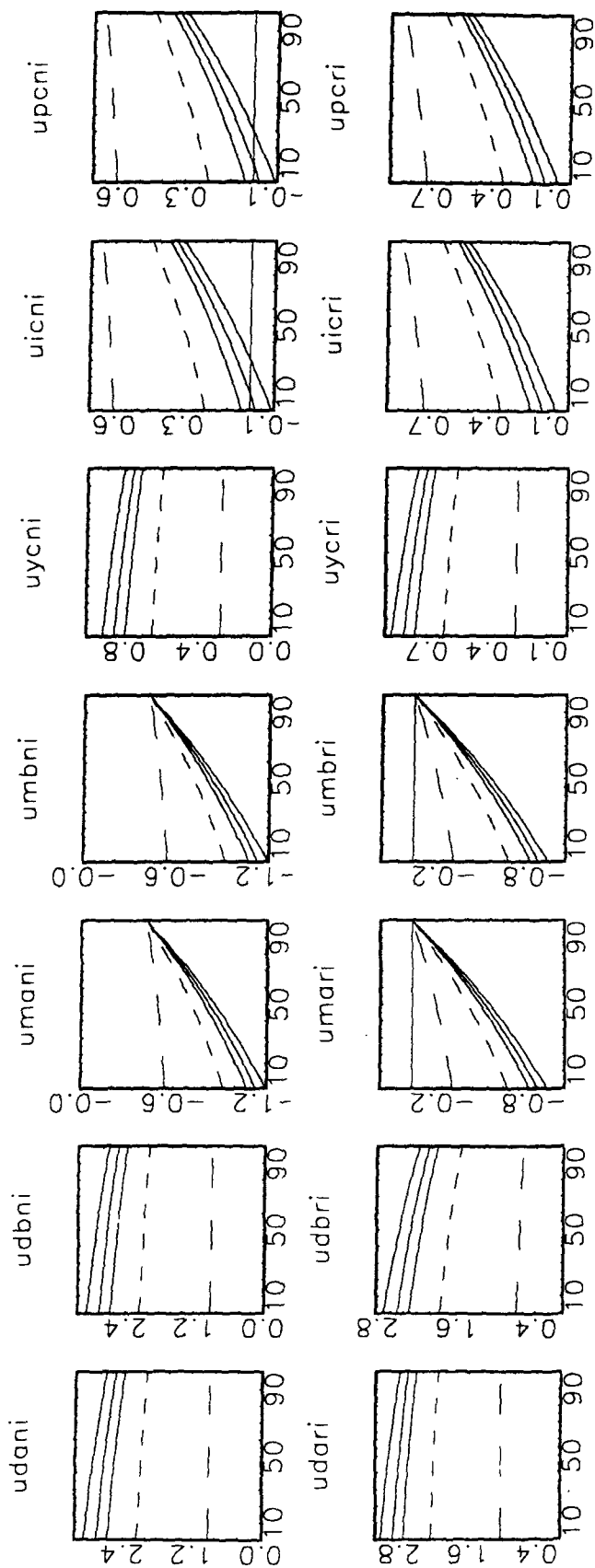


Figure 5

