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### **International interdependence and policy coordination in economies with real and nominal wage rigidity**

van der Ploeg, F.

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Rigidity

by  
Frederick van der Ploeg

Reprinted from Greek Economic Review,  
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**Address:** Hogeschoollaan 225, P.O. Box 90153, 5000 LE Tilburg, The Netherlands

**Phone :** +31 13 663050

**Telex :** 52426 kub nl

**Telefax:** +31 13 663066

**E-mail :** "center@htikub5.bitnet"

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# INTERNATIONAL INTERDEPENDENCE AND POLICY COORDINATION IN ECONOMIES WITH REAL AND NOMINAL WAGE RIGIDITY

*By Frederick van der Ploeg\**

## I. INTRODUCTION

Most of the policy debate about the performance of the OECD economies in the eighties seems to be concerned with the relative tightness of Europe's fiscal policy and the relative looseness of US fiscal policy. Many commentators have urged Europe to engage in a fiscal expansion and the US to engage in a fiscal contraction (e.g., Layard et al., 1984),<sup>1</sup> but neither of the governments on the two sides of the Atlantic have been particularly keen to implement these recommendations. The main objectives of this paper are to understand these suggestions for economic policy, to understand why the European governments and the US government have no apparent desire to implement them, and in particular to understand why recovery in Europe seems so hard. The framework that will be used is a two-country model with asymmetries in aggregate supply, i.e., nominal wage rigidity in the US and real wage rigidity in Europe (cf., Branson and Rotemberg, 1980), and then elementary differential game theory is used to assess the potential merits of international policy coordination. Before these particular issues are addressed, it is useful to review the assumptions underlying the standard Mundell-Fleming models and the consequent effects of fiscal and monetary policy on output and employment.

In the traditional one-country Mundell-Fleming world with floating exchange rates and perfect capital mobility a monetary expansion is doubly

\* Financial support from the Economic and Social Research Council, the Ford Foundation, the Alfred P. Sloan Foundation and the Centre for Economic Policy Research is gratefully acknowledged. The author is grateful to Stewart Robertson for the preparation of the graphs of the main economic indicators for the seven largest OECD economies.

1. "There is world-wide agreement, it seems, that the prospective US long-run deficits are harmful to the world economy. It is also the case, less generally agreed, that European recovery is too slow and too precarious. The natural conclusion is some intertemporal trade: more rapid European recovery through fiscal stimulus traded off for reduced long-run US deficits" (Layard et al., 1984, p. 63).

powerful, because the incipient capital outflows (induced by the downward pressure on interest rates) are choked off by a depreciation of the exchange rate and this results in a further increase in aggregate demand. A fiscal expansion leads to incipient capital inflows, which are choked off by an appreciation of the exchange rate. The contraction in net exports completely crowds out the increase in government spending, so that a fiscal expansion has no effects on output. The Mundell-Fleming model of a small open economy assumes fixed prices of goods and labour and only considers aggregate demand; it also ignores expectational dynamics. A more fully specified model also considers aggregate supply. The Mundell-Fleming model assumes nominal wage rigidity, but the policy results are reversed when there is real wage rigidity. In that case a monetary expansion has no real effects and simply leads to a one-for-one increase in prices and wages, so that a fully indexed economy is insulated from monetary shocks. However, a fiscal expansion leads to an appreciation of the real exchange rate and therefore to a reduction in the wedge between the producers' and consumers' wage. This leads to an increase in output and employment (Casas, 1975; Argy and Salop, 1977; Sachs, 1980, van de Klundert and van der Ploeg, 1989). Hence, the qualitative conclusions on the effectiveness of monetary and fiscal policies are not robust to the degree of real or nominal wage rigidity. However, employers' subsidies or cuts in employers' taxes increases output and employment in a small open economy irrespective of whether nominal or real wages are rigid (Argy and Salop, 1977). In the first case, the cut in employers' taxes reduces the price level, increases the real money supply and therefore increases aggregate demand. In the second case, the wedge between the producers' and consumers' wage is reduced and therefore aggregate supply is increased.

In the two-country Mundell-Fleming world a home monetary expansion increases net exports of the home country, so that home output increases and foreign output decreases. In other words, monetary expansion is a beggar-thy-neighbour policy. Similarly, fiscal expansion is a locomotive policy. The nature of these spill-over effects depend on the assumption of nominal wage rigidity in both countries. When both countries have real wage rigidity, monetary expansion has no real effects whilst fiscal expansion is a beggar-thy-neighbour policy (as the associated appreciation of the real exchange rate increases the foreign wedge). More interestingly, when Europe has real wage rigidity and the US has nominal wage rigidity, a European fiscal expansion and a US monetary expansion are locomotive policies whilst a US fiscal expansion is, typically, a beggar-thy-neighbour policy (e.g., Argy and Salop, 1983).<sup>2</sup> This

2. Similar results for the effectiveness of fiscal and monetary policy in two-country models with nominal and real wage rigidity are discussed in Oudiz and Sachs (1984).

implies that, in the absence of international policy coordination, the European fiscal stance is too tight from the US point of view and too loose from the European point of view whilst US fiscal policy is, typically, too loose (see Section 6). Some German commentators might have a world with the "law of one price" (purchasing power parity) in mind, because they argue that (European) fiscal policy has no real effects whatsoever (as it cannot affect the wedge) and therefore should be set at a level consistent with no inflation. Such an asymmetric two-country model allows one, as has been pointed out by Branson and Rotemberg (1980) before, to understand the recent suggestions for international policy coordination and at the same time to understand why recovery in Europe is so hard.

Simple differential game theory is usually used to assess the merits of international policy coordination (see Hamada (1985) for the pioneering work in this area). For example, Miller and Salmon (1985), Currie and Levine (1985), and Oudiz and Sachs (1985) use symmetric two-country real-exchange-rate overshooting models with nominal wage rigidity and the natural rate hypothesis to investigate the gains from coordination in the transient phase when countries are involved in monetary disinflation. Since reductions in monetary growth in such models are a beggar-thy-neighbour policy, the non-cooperative Nash equilibrium solution gives rise to excessively fast disinflation relative to the cooperative solution. These results assume that the Central Banks can pre-commit themselves, but when they cannot international policy coordination may be counter-productive (Rogoff, 1985; van der Ploeg, 1988). The point is that, in the absence of coordination, a surprise increase in monetary growth induces a depreciation of the exchange rate and leads to inflation costs whilst, in the presence of coordination, such a disincentive does not exist, hence coordination exacerbates the credibility problems and becomes counter-productive. It is also possible that coordination between two countries (say, France and Germany) is counter-productive, because it may provoke an adverse response from a third country (say the US) (e.g., Canzoneri and Henderson, 1986). Interesting empirical work in this area has only just started (e.g., Oudiz and Sachs, 1984; McKibbin and Sachs, 1986). The present paper builds on this work and attempts to assess the merits of coordination of fiscal and supply-side as well as monetary policies in two-country models with real as well as nominal wage rigidity.

The four main objectives of this paper are : (i) to provide new empirical evidence on real and nominal wage rigidity in the OECD economies; (ii) to develop a convenient diagrammatic exposition that can be used for teaching purposes to analyse the spill-over effects of fiscal, monetary and supply-side policies in a two-country model with floating exchange rates, perfect capital

mobility and real and/or nominal wage rigidity; (iii) to analyse, with the aid of simple game theory, the nature of the bias in economic policies arising from the lack of international policy coordination; and (iv) to analyse the effects of an oil shock in a two-country model with real wage rigidity at home and nominal wage rigidity abroad.

Section 2 examines the development of unemployment, inflation, competitiveness, interest rates, monetary policy, fiscal stance and supply-side policies in the seven largest OECD economies during the seventies and eighties. Section 2 also estimates annual wage equations, of the error-correction type, for these economies and tests which economies have a significant degree of nominal wage rigidity in the short run. It turns out that Canada, the UK and the US show evidence of nominal wage rigidity, but that France, Germany, Italy and Japan have real wage rigidity. Section 3 then sets up an analytical two-country model with floating exchange rates, uncovered interest parity, imperfect substitution between home and foreign goods, and sluggish labour markets. For each country two extreme cases of nominal and real wage rigidity can be considered, that is either growth in nominal wages is given by monetary growth or the real consumers' wage is constant. It follows that the only dynamics in this model then arises from the perfect-foresight dynamics of the real exchange rate, so that for unanticipated permanent shocks the transition to the new equilibrium is instantaneous. Section 4 considers a world with nominal wage rigidity at home and abroad, which is closest to the conventional Mundell-Fleming world, and develops a convenient diagrammatic apparatus to analyse the spill-over effects of various economic policies. It is shown that an expansion in monetary growth and a cut in taxes are beggar-thy-neighbour policies as they lead to a fall in the world real interest rate, an excess demand for foreign money, a downward pressure on the foreign price level, and therefore an increase in the foreign real wage and fall in foreign output. Fiscal expansion is a locomotive policy. Section 4 also assesses the merits of international policy coordination with the aid of discounted social welfare loss functions that depend on output and inflation in the consumers' price index. In the absence of international policy coordination, optimal monetary growth is too high and time-inconsistent. Section 5 considers a world with real wage rigidity at home and abroad. Now monetary growth has no real effects, fiscal expansion is a beggar-thy-neighbour policy (as the associated appreciation of the real exchange rate increases the wedge between the foreign producers' and consumers' wage), and supply-side improvements are a locomotive policy (as they lead to a depreciation of the real exchange rate and therefore to a fall in the foreign wedge). Section 5 also employs discounted social welfare loss functions, that depend on output and the public deficit, to

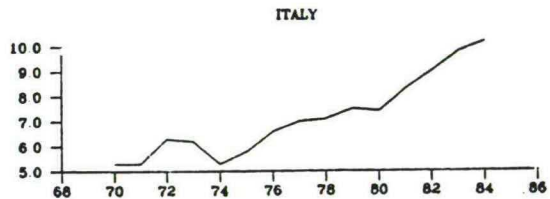
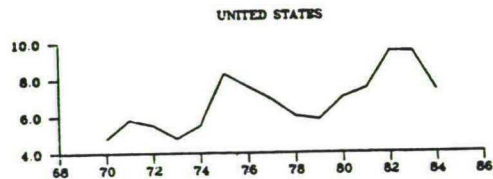
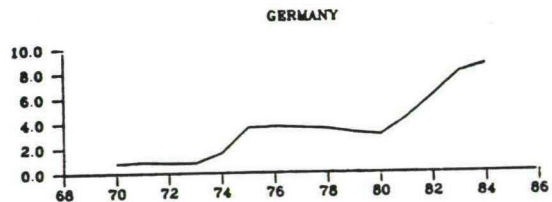
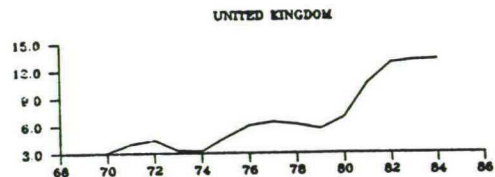
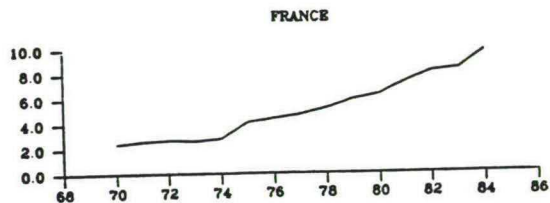
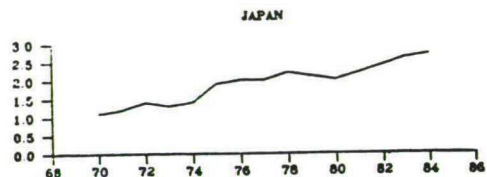
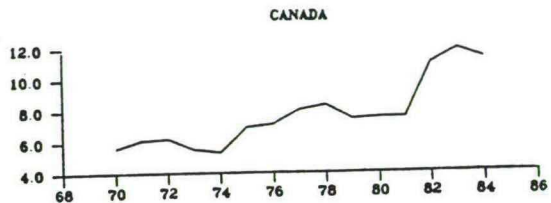


show that in the absence of coordination fiscal policy is too loose and time-inconsistent. It also contains a brief discussion on the optimal coordination of monetary growth rates in a world with pegged exchange rates. Section 6 considers an asymmetric world with real wage rigidity at home (Europe and Japan) and nominal wage rigidity abroad (Canada and US). Now a European fiscal expansion, an increase in US monetary growth and a US tax cut are locomotive policies whilst a European tax cut and, typically, a US fiscal expansion are beggar-thy-neighbour policies. Oil price shocks typically hit European output and employment much harder than US output and employment. It follows that, in the absence of international coordination and in the aftermath of the OPEC oil shocks, the European fiscal stance is too tight from the US point of view and too loose from the European point of view whilst the US fiscal stance is, typically, too loose, and the US monetary growth rate is too low. Section 7 concludes the paper.

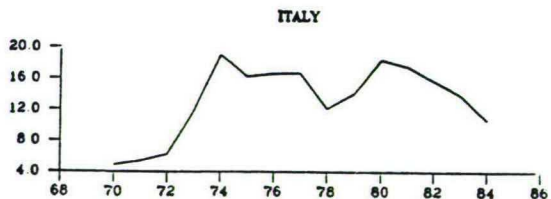
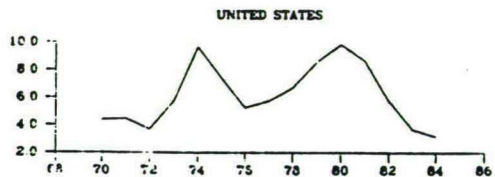
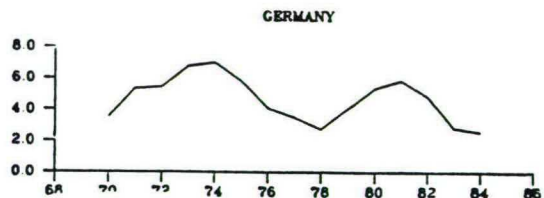
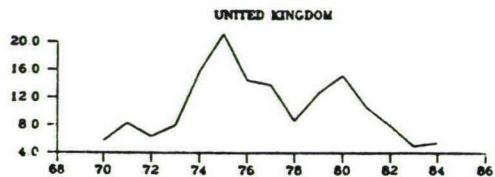
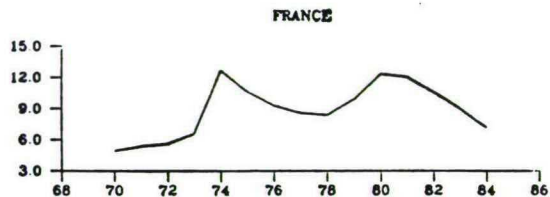
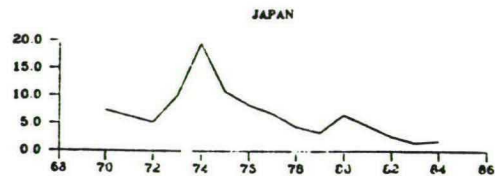
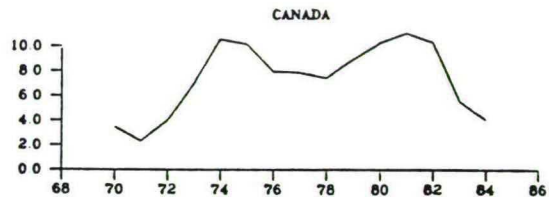
## II. THE MAIN OECD ECONOMIES

### II.1 *Economic Developments in the Seventies and Eighties*

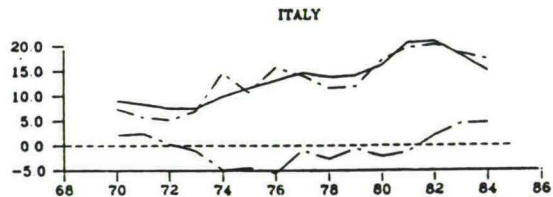
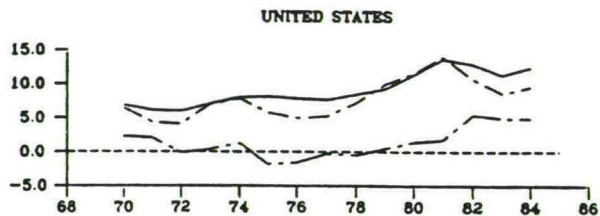
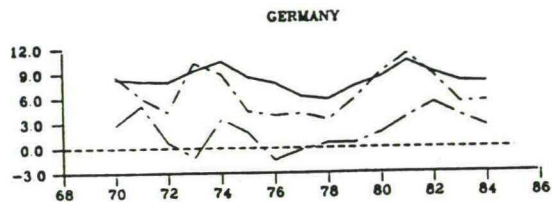
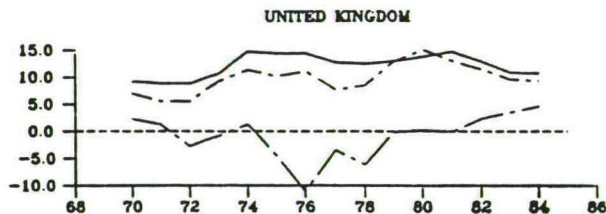
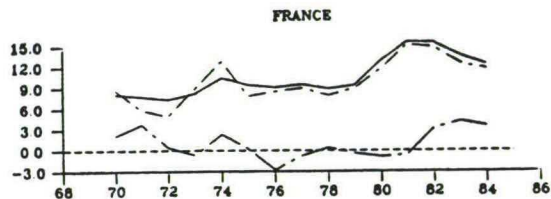
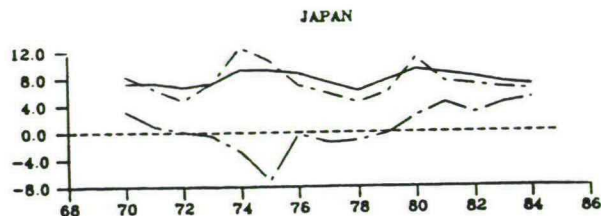
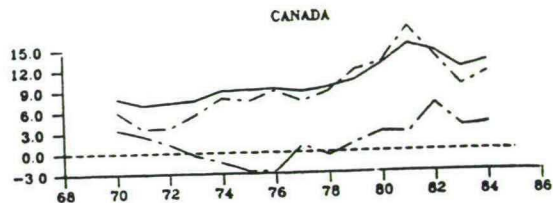
Graph 1 shows the standardised unemployment rates for the economies of the Group of Seven during the period 1970-1984. In all economies, except the US, there has been a steady rise in the unemployment rate since 1970. The rise in the unemployment rate has been particularly dramatic for the European economies. For example, for the UK it has risen from 3 per cent in 1970 to 13.2 per cent in 1985, for Italy from 5.3 per cent to 10.5 per cent, for Germany from 0.8 per cent to 10.6 per cent and for France from 2.4 per cent to 10.1 per cent. It is well known that the rise in European unemployment is mainly due to the failure to create sufficient jobs rather than due to increases in the labour force or other demographic factors (e.g., Newell and Symons, 1987). The US economy seems to have adjusted much better to the OPEC shocks of 1973 and 1979 than the other economies, since its unemployment rate has risen from 4.8 per cent in 1970 to a peak of 8.3 per cent in 1975 and another peak of 9.5 per cent in 1982/83 and has fallen to 7.1 per cent in 1985. The recessions in the US seem to be shorter and deeper than elsewhere, which may be due to the US adjusting employment more rapidly than the wage. In contrast to the US economy, the Canadian economy has seen its unemployment rate rise fairly steadily from 5.6 per cent in 1970 to 10.4 per cent in 1985. The Japanese economy has very low unemployment rates and has seen a modest increase from 1.1 per cent in 1970 to 2.6 per cent in 1985, but these figures are probably an under-estimate (Hamada and Kurosaka, 1986). Graph 2



GRAPH 1. Standardised unemployment rates.

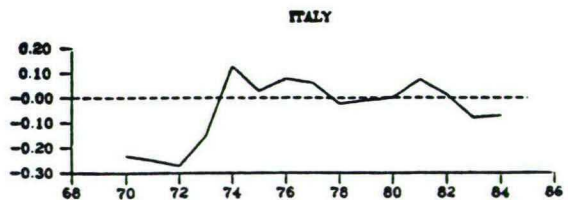
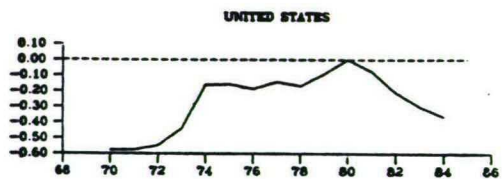
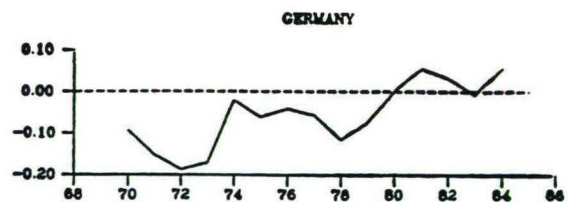
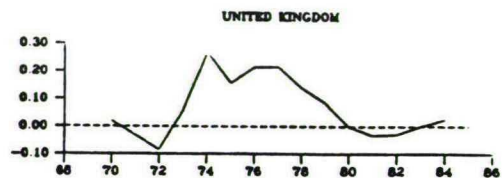
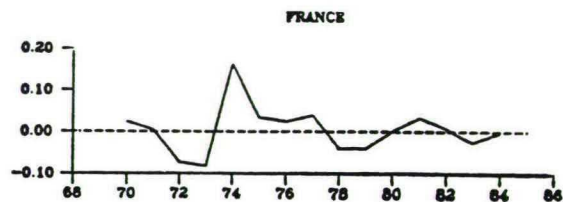
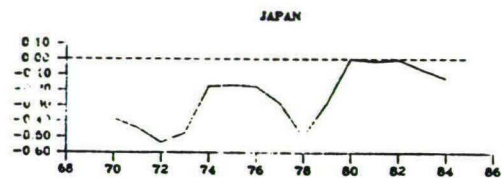
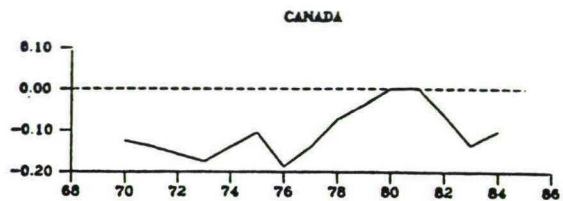


**GRAPH 2.** Annual percentage inflation in the deflator of consumers expenditure.

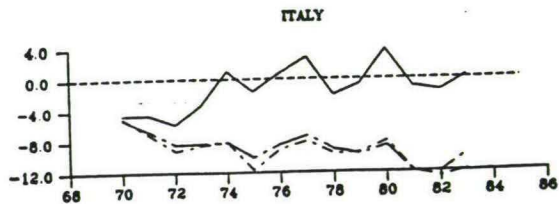
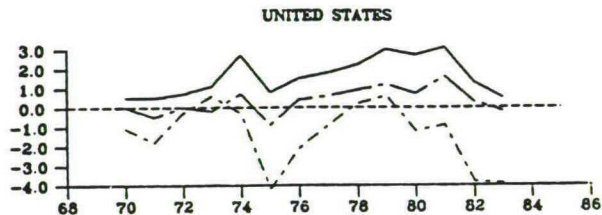
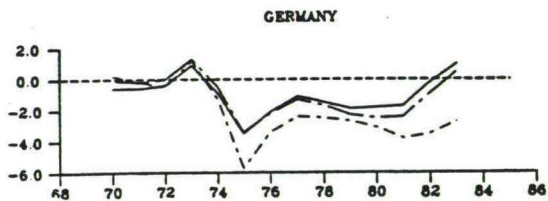
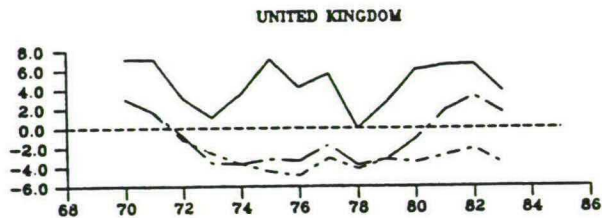
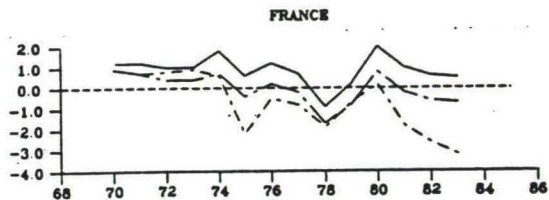
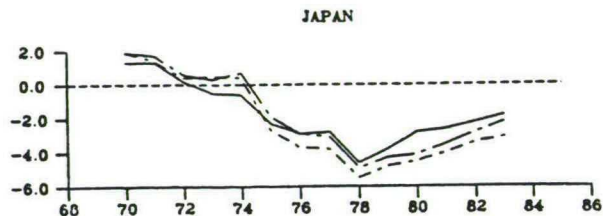
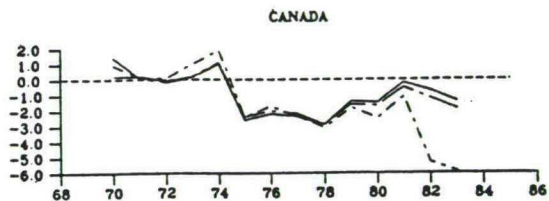


GRAPH 3. Interest rates

- - - Short realised real rate of interest  
 - - - Short nominal rate of interest  
 ——— Long nominal rate of interest

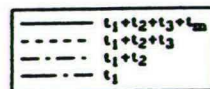
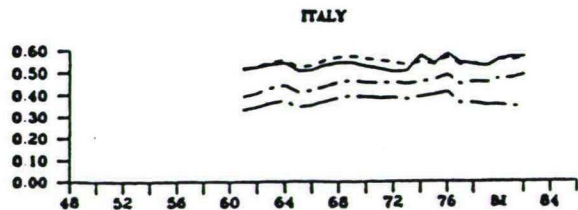
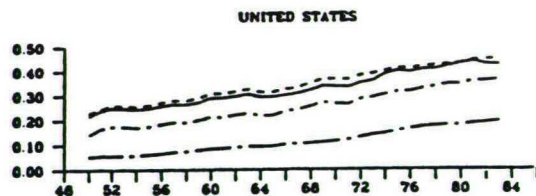
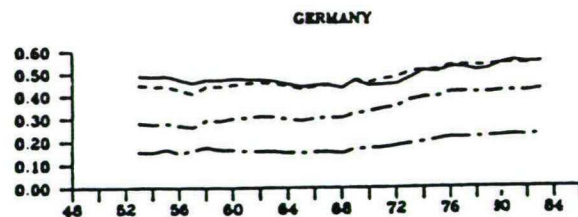
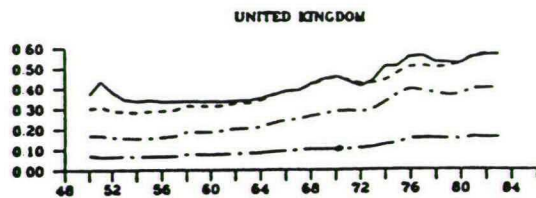
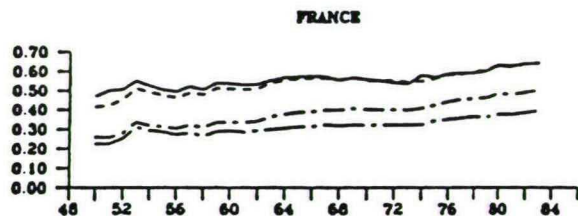
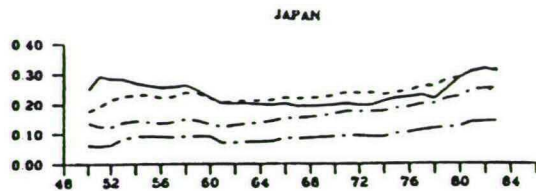
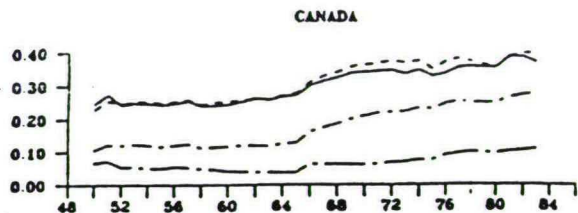


**GRAPH 4.**  
Index of real competitiveness  $\log(P_m) - \log(P)$ .



---	Actual budget balance
— — —	Structural budget balance
— — — —	Inflation-adjusted budget balance

GRAPH 5.



**GRAPH 6.** Composition of the wedge between the producers and the consumers wage.

shows the annual percentage inflation in the deflators of consumers' expenditures. Apart from Germany, the European economies have relatively high inflation rates. For all countries there are peaks in the inflation rates around 1974 and 1980 which are related to the two OPEC shocks in oil prices, and subsequently there are steady falls in inflation rates, which are related to the tightening of monetary policy in the Group of Seven during the 1980s. Graph 3 shows various interest rates. Most of the economies of the Group of Seven have very low (even negative) realised real interest rates during the 1970s and quite a large rise in real interest rates during the 1980s, which again is a result of the tightening of monetary policy in the 1980s. Graph 4 shows the indices of real competitiveness. The US (and to a lesser extent Canada) experienced a gradual increase in the real price of imports, associated with an increase in raw material prices and depreciation of the US real exchange rate, until 1980 and subsequently a gradual fall in the real price of imports, associated with appreciation of the US real exchange rate. The UK has experienced appreciation of its real exchange rate since 1974, which may be due to the advent of North Sea oil and later on due to the Thatcher experiment. However, since 1981 this trend in the UK has been reversed. Europe as a whole has seen a loss of competitiveness up to 1980, with a gain since then.

Graph 5 shows various government budget surpluses. Even when one corrects for the business cycle and for inflation, the US, Canada and France have loosened their fiscal stance whilst Germany, Italy, the UK and especially Japan have tightened their fiscal stance during the 1980s. Hence Europe (ignoring the Mitterrand experiment in France) and Japan have recently tightened their fiscal stance whilst the US and Canada have loosened their fiscal stance. One of the main objectives of this paper is to explain these differences in fiscal stance (see Section 6). It will be argued that a European or Japanese fiscal expansion is a locomotive policy, so that in the absence of coordination their fiscal expansion is too tight from the US point of view. However, a US or Canadian fiscal expansion is, typically, a beggar-thy-neighbour policy and therefore their fiscal stance is, typically, too loose. This insight helps to understand why during the 1980s European unemployment has risen so much, world interest rates have risen, and the European (US) real exchange rate has depreciated (appreciated) (see Graphs 1, 3, 4 and 5). Graph 6 shows the composition of the wedge between the producers' wage and the consumers' wage. The wedge is the sum of the employers' tax rate ( $\tau_1$ ), the employees' tax rate ( $\tau_2$ ), the indirect tax rate ( $\tau_3$ ), and the share of imports in total expenditures times the wedge between the import price and the output price ( $\tau_m$ ). The wedge is one of the indicators of supply-side policy. In most countries the wedge has risen steadily throughout the post-war period. For the US the



wedge has increased from 24.8 per cent in 1953 to 42.2 per cent in 1983, for Canada from 24.7 per cent to 36.6 per cent, for France from 54.9 per cent to 63.6 per cent, for Germany from 48.9 per cent to 55.1 per cent, and for the UK from 34.6 per cent to 57.0 per cent. Hence, the rise in the wedge has been particularly spectacular for the UK and the US. For Italy the rise in the wedge has been modest, from 51.4 per cent in 1961 to 56.5 per cent in 1983. The trend increase in the wedge is due to the steadily rising burden of taxation in the OECD economies, which no doubt has had an adverse effect on the NAIRU's of these economies. However, fluctuations of the wedge around trend have been mainly due to fluctuations in the import price wedge and the real exchange rate (also see Graph 4). For example, during the eighties, the tightening of the European fiscal stance and the loosening of the US fiscal stance might have contributed to the depreciation of the European real exchange and consequently to the increase in the European wedge, the worsening of European supply and the increase in the European unemployment rate (see Graphs 1, 4, 5 and 6 and the discussion in Section 6).

## 11.2 *Empirical Evidence for Real and Nominal Wage Rigidity*<sup>3</sup>

It has been argued that the US economy has stickiness of nominal wages (money illusion) and that the European and Japanese economies have real wage rigidity (Branson and Rotemberg, 1980; and Bruno and Sachs, 1985). This section employs annual, time-series data for the 7 largest economies of the OECD to test whether the above hypothesis is valid. The sample period is 1955-83, except for Italy and Japan for which it is 1962-83. The following regression model has been estimated for each of these countries (see Attanasio, Manasse and van der Ploeg, 1987):

$$\begin{aligned} \Delta w = & \alpha_0 + \alpha_1 \Delta p_c + (1 - \alpha_1) \Delta w_{-1} - \alpha_2 u - \alpha_3 \Delta u + \alpha_4 PROD \\ & + \alpha_5 NC - \alpha_6 (w - \tau_2 - p_c) + \varepsilon, \end{aligned} \quad (2.1)$$

where  $w$ ,  $p_c$ ,  $\tau_2$ ,  $u$ ,  $PROD$ ,  $NC$  and  $\varepsilon$  denote the logarithm of the nominal wage, the logarithm of the consumers' price index, the employees' (direct) tax rate, the unemployment rate (except for Japan for which it is the ratio of jobs wanted to jobs offered), the trend (three-year moving average) of the logarithm

3. The regression results in this Section have been obtained by Orazio Attanasio and are part of the London School of Economics Econometric Model of the Group of Seven (Attanasio, Manasse and van der Ploeg, 1987).

of the output-employment ratio, a measure of industrial conflicts (except for the UK for which it is an incomes policy dummy), and a white-noise error term, respectively.

Equation (2.1) is an error-correction mechanism (Sargan, 1964), which ensures that the (post-tax real) consumers' wage,  $w - \tau_2 - p_c$ , always returns to its long-run equilibrium value  $(\alpha_0 - \alpha_1\rho - \alpha_2u + \alpha_4PROD + \alpha_5NC)/\alpha_6$  ( $\alpha_6 > 0$ ) where  $\rho$  denotes the feasible growth in real wages (trend growth in labour productivity). The long-run consumers' wage increases when the bargaining strength of workers or "wage push" increases, i.e., when unemployment falls ( $\alpha_2 > 0$ ) and labour productivity, increases ( $\alpha_4 > 0$ ), and when the firms' ability to pay, i.e., the feasible growth in real wages decreases ( $\alpha_1 > 0$ ). There may also be hysteresis effects (Blanchard and Summers, 1987), so that changes in (rather than the levels of) the unemployment rate determine the bargaining strength of workers ( $\alpha_3 > 0$ ). One reason for hysteresis is that the long-term unemployed do not actively seek for a job and therefore do not exercise a downward pressure on wages. An alternative explanation is based on an analysis of insiders versus outsiders.

To allow for some nominal inertia in the short run, the growth in nominal wages is assumed to depend on a weighted average of inflation in the consumers' price index and past growth in nominal wages ( $0 < \alpha_1 \leq 1$ ). When wages are instantaneously indexed to the consumers' price level ( $\alpha_1 = 1$ ), there is no nominal inertia or money illusion and therefore one has *real wage rigidity*. When there are lags in the process of wage indexation ( $\alpha_1 < 1$ ), one has *nominal wage rigidity*.<sup>4</sup> Note that the homogeneity of (2.1) ensures that in the long run, the growth in nominal wages is fully indexed to inflation in the consumers' price index and therefore in the long run real wage rigidity always prevails. An alternative interpretation is that core inflation influences wage inflation one-for-one and that core inflation equals current inflation in the consumers' price index under "rational expectations" (real wage rigidity) and is a weighted average of past rates of inflation in the consumers' price index under "adaptive expectations" (nominal wage rigidity). However, the interpretation of  $\alpha_1$  as an adjustment coefficient in the indexation process seems preferable.

Table 1 presents the regression results for Canada (CA), France (FR) Germany (GE), Italy (IT), Japan (JA), UK and US. All the equations appear, to be well determined, the reported diagnostics show no signs of misspecifi-

4. When lags in price formation are ignored,  $(\alpha_1/\alpha_2)$  is a measure of real wage rigidity and  $(1 - \alpha_1)/\alpha_2$  is a measure of nominal wage rigidity (see Grubb, Jackman and Layard, 1983, but strictly speaking these measures are derived for the case  $\alpha_6 = 0$ ).

TABLE 1  
 Econometric Estimates of Wage Equations for the Main OECD Economies

$\Delta w$	CA	FR	GE	IT	JA	UK	US
Constant	-0.785	-0.569	-2.235	-1.310	-0.014	-0.810	-0.306
t-ratio	2.09	3.26	3.52	3.48	0.05	2.73	1.65
$\Delta p_c^a$	0.632	0.913	0.808	0.992	0.895	0.717	0.641
t-ratio	5.81	7.28	4.63	7.26	7.90	5.65	4.40
$\Delta w_{-1}^a$	0.368	0.087	0.192	0.008	0.105	0.283	0.359
t-ratio	3.38	0.69	1.10	0.06	0.93	2.23	2.47
$u^b$	-0.444	-0.164	-1.458	-1.367	-0.083	-0.350	
t-ratio	2.22	6.56	5.02	1.62	3.02	1.77	—
$\Delta u$	—	-1.750	—	—	—	—	-0.514
t-ratio		1.85					2.90
PROD	0.202	0.069	0.561	0.282	0.062	0.366	0.071
t-ratio	1.85	2.30	3.58	2.71	0.59	2.87	1.23
NC <sup>c</sup>	0.0084	0.035	—	0.0391	0.0082	-0.0796	0.0113
t-ratio	2.07	4.07		2.43	0.45	5.49	1.92
$w-\tau_2 \cdot p_c$	-0.200	-0.073	-0.565	-0.225	-0.087	-0.338	-0.130
t-ratio	1.88	1.56	3.83	2.79	0.78	2.72	1.62
Standard Error	0.0094	0.0112	0.0174	0.0256	0.0145	0.0163	0.0083
SARGAN <sup>d</sup>	9.97	11.23	10.54	8.25	8.37	6.79	11.41
d.f.	6	7	8	8	6	7	8
LM1 <sup>e</sup>	0.27	0.11	0.03	1.07	1.14	1.16	0.49
HETERO <sup>f</sup>	7.26	0.09	0.01	0.16	0.14	0.45	1.29

## Notes :

a) These coefficients have been restricted to add up to unity. The restrictions were not rejected at the 5 per cent significance level.

b) The unemployment rate statistics for JA are not a very good measure of labour market conditions (Hamada and Kurosaka, 1986), hence instead the series of the ratio of jobs wanted to jobs offered has been used.

c) For CA and IT, this is the logarithm of the number of days lost through strikes (lagged). For FR, this is the logarithm of the number of conflicts. For the US, this is the logarithm of the number of conflicts (lagged). For the UK, this is an incomes policy dummy for the years 1976-77.

d) Sargan's test for serial correlation of IV residuals (Breusch and Godfrey, 1981, Appendix B).

e) Test for residual serial correlation (Godfrey, 1987)

f) Test for homoskedasticity (White, 1980).

cation, and all coefficients are significant and of the right sign or insignificant at the 5 per cent level. The main point to notice is that the null hypothesis that there is real wage rigidity cannot be rejected at the 5 per cent significance level for FR, GE, IT and JA, because the coefficients on  $\Delta w_{-1}$  (i.e.,  $1 - \alpha_1$ ) are insignificantly different from zero. CA, the US and, to a lesser extent, the UK do have a significant degree of nominal inertia. Hence, the European economies (apart from the UK) and the Japanese economies can be characterised by real wage rigidity whilst the Canadian and US economies have a significant degree of nominal wage rigidity.

### III. A TWO-COUNTRY WORLD WITH FLOATING EXCHANGE RATES AND UNCOVERED INTEREST PARITY

Consider a two-country world with floating exchange rates, highly integrated and efficient financial markets, and sluggish labour markets. The asset menu consists of home cash, home government bonds and foreign government bonds. There is imperfect substitution between home and foreign goods, but perfect substitution between home and foreign government bonds. Firms produce goods at home and can sell either at home or abroad. The goods and money markets clear instantaneously, but the labour market does not clear due to rigidity of either nominal wages or of real consumers' wages. Indexation of the wage rate to increases in the cost-of-living, arising from increases in consumers' prices or tax rates, is an important feature of the European and Japanese economies whilst nominal wage rigidity is an important feature of the US and Canadian economies (see Section 2). The government has three policy instruments at its disposal, viz. open-market operations (money supply), changes in public spending (fiscal shock) and various forms of supply-side policies (e.g., wage push or marginal tax rates). The residual mode of government finance is bond issues. The analysis abstracts from wealth effects, current-account dynamics, intertemporal government budget constraints and commercial banking systems.

The two-country model consists of the following equations :

$$y = -\bar{\sigma}r + \bar{\delta}c + \bar{f} + \gamma y^*, \quad 0 \leq \gamma < 1 \quad (3.1)$$

$$y^* = -\bar{\sigma}r^* - \bar{\delta}c + \bar{f}^* + \gamma y \quad (3.2)$$

$$r \equiv i - E\dot{p}_c \quad (3.3)$$

$$r^* \equiv i^* - E\dot{p}_c^* \quad (3.4)$$

$$c \equiv p^* + e - p \quad (3.5)$$

$$m - p = \varphi y - \lambda i \quad (3.6)$$

$$m^* - p^* = \varphi y^* - \lambda i^* \quad (3.7)$$

$$i = i^* + E\dot{e} \quad (3.8)$$

$$\dot{p}_c = (1 - \alpha)\dot{p} + \alpha(\dot{p}^* + \dot{e}) \quad (3.9)$$

$$\dot{p}_c^* = (1 - \alpha)\dot{p}^* + \alpha(\dot{p} - \dot{e}) \quad (3.10)$$

$$y = -\bar{\beta}_1[(w + \tau - p) + \bar{\beta}_2(p_n^* + c)] + \bar{\beta}_3 \quad (3.11)$$

$$y^* = -\bar{\beta}_1^*[(w^* + \tau^* - p^*) + \bar{\beta}_2^*p_n^*] + \bar{\beta}_3^* \quad (3.12)$$

$$\dot{w} = \pi + ky \quad (3.13)$$

$$\dot{w}^* = \pi^* + ky^* \quad (3.14)$$

$$\dot{\pi} = \zeta(\dot{p}_c - \pi) \quad (3.15)$$

$$\dot{\pi}^* = \zeta(\dot{p}_c^* - \pi^*) \quad (3.16)$$

where  $y$  = real output

$p$  = producers' price level

$\bar{f}$  = real fiscal shock (public deficit)

$m$  = nominal money supply

$i$  = nominal interest rate

$r$  = real interest rate

$e$  = nominal exchange rate

$c$  = real exchange rate

(relative price of foreign goods in terms of home goods)

$w$  = nominal wage rate

$p_c$  = consumers' price level

$\pi$  = core rate of inflation in the cost-of-living index

$\tau$  = employers' tax (contributions) rate

$p_n^*$  = real price of imported raw materials.

The variables  $r$ ,  $i$  and  $\tau$  are ratios expressed as arithmetic differences from their steady-state values. All other variables are expressed as logarithmic deviations from their steady-state values. Foreign variables are denoted by an asterisk.

Equations (3.9) - (3.10) give the cost-of-living indices as weighted averages of home and foreign prices. The share of imports in total expenditures is  $\alpha$ , which is constant for Cobb-Douglas preferences. Equations (3.3) - (3.5) define the real rates of interest and the real exchange rate. Equation (3.8) is the uncovered interest parity condition, which says that the differential between the return on home and foreign government bonds must equal the expected depreciation of the exchange rate. It holds when there are no exchange controls and when agents engage in risk-neutral arbitrage. These equations yield

$$r - r^* = (1 - 2\alpha) E\dot{c}, \quad (3.17)$$

so that the differential in real interest rates is always zero when the share of foreign goods in total households' expenditures is 50 per cent. Equations (3.1) - (3.2) are the IS-curves, which say that aggregate demand for goods increases when the real interest rate or the relative price of home goods falls, when there is a fiscal expansion, and when there is an expansion of demand abroad. Upon substitution of (3.17) into (3.1) - (3.2), one obtains the AD-schedules :

$$y = -\sigma r + \delta c + f + \gamma f^* + \gamma \eta E\dot{c} \quad (3.18)$$

$$y^* = -\sigma r - \delta c + f^* + \gamma f + \eta E\dot{c} \quad (3.19)$$

where

$\sigma \equiv \bar{\sigma} / (1 - \gamma)$ ,  $\delta \equiv \bar{\delta} / (1 + \gamma)$ ,  $f \equiv \bar{f} / (1 - \gamma^2)$  and  $\eta \equiv (1 - 2\alpha) \sigma / (1 - \gamma^2)$ . Equations (3.6) - (3.7) are the LM-curves, which show that the demand for money increases with national income and decreases with the nominal interest rate.]

Firms produce at home and sell in both the home and foreign markets. The market environment is one of monopolistic competition. Labour and imported raw materials are the factors of production. It is assumed that the price of the imported input, say oil, is indexed to the foreign (US) price level. This leads to an asymmetry in the specification of aggregate supply for Europe and the US (Canzoneri and Gray, 1985); a real appreciation of the European (home) currency decreases the relative price of raw materials to Europe and therefore increases European production of goods whilst US (foreign) output is unaffected. Obviously, an increase in the real producers'

wage,  $w + \tau - p$ , leads to a reduction in the demand for labour and the supply of goods. The above ideas are captured in equations (3.11) - (3.12).<sup>5</sup> An interesting feature is that, as long as the price elasticities of the demand function for the products of an individual firm are constant, aggregate supply does not depend directly on the real exchange rate despite the fact that allowance has been made for imperfect competition on both the home and foreign markets. Branson and Rotemberg (1980) argue that the relevant producers' price is an average of the price they can fetch on the home market and the price they can fetch on the foreign market, but it is not clear how their model of discriminating monopolists can be consistent with this idea. This means that their argument that an appreciation of the real exchange rate increases the real producers' wage and cuts aggregate supply may not hold.

Equations (3.13) - (3.14) are the expectations-augmented Phillips curves.<sup>6</sup> Equations (3.15) - (3.16) show that the expected rates of inflation adjust gradually to the rates of inflation in the cost-of-living indices. Alternatively, one can interpret the parameters  $\zeta$  and  $\zeta^*$  as the speeds of indexation at home and abroad, respectively. The special case of real wage rigidity (*RWR*) corresponds to an infinite speed of indexation to increases in the cost of living. Section 2 showed that *RWR* cannot be rejected at the 5 per cent significance level for the French, German and Italian economies and that the UK economy is very close to *RWR*. The Canadian and US economies display nominal wage rigidity

5. Capital letters denote actual levels (rather than deviations). Firm  $i$  maximises its profits,  $P_i Y_i - (1 + \tau) W L_i - P_n^* E P^* N_i$ , subject to the demand function for its products,  $Y_i = K(P_i/P) - \eta_1 (P_i/P^* E) - \eta_2$ , where the constant  $K$  increases with aggregate output ( $Y$ ) and the real exchange rate ( $P^* E/P$ ) and the elasticities ( $\eta_i$ ) are constant, and its production function,  $Y = f(L_i, N_i)$  where  $f(\cdot)$  exhibits decreasing returns to scale (as there may be other factors, such as capital, that are fixed). The demand functions imply that each firm competes both with other home firms and with other foreign firms. Profit maximisation yields the conditions that the marginal revenue product of each factor should equal the real factor price, that is  $(1 - \eta^{-1}) f_{L_i}(L_i, N_i) = W(1 + \tau)/P_i$  and  $(1 - \eta^{-1}) f_{N_i}(L_i, N_i) = P_n^* E P^*/P_i$  where  $\eta \equiv \eta_1 + \eta_2$ . Symmetry yields  $P_i = P$ . These two first-order conditions yield the optimal demand for labour and raw materials (and thus aggregate output) as functions of the real producers' wage,  $W(1 + \tau)/P$ , and the real cost of raw materials,  $P_n^* C$ . Obviously, the demand for each factor decreases with the price of the own factor price. When factors are cooperant ( $f_{L_i N_i} > 0$ ), the output effect dominates the substitution effect and therefore the demand for labour (raw materials) decreases with the real price of raw materials (labour). Equations (3.11) - (3.12) follow from log-linearisation and are exact for Cobb-Douglas production functions. The strength of the effects of relative factor prices diminishes when the elasticity of substitution between labour, raw materials and other fixed factors is low.

6. The alternative of overlapping wage contracts (combined with price rigidity) embedded within a numerical two-country model is discussed in Attanasio and van der Ploeg (1988).

(*NWR*) since the hypothesis of *RWR* was rejected at the 5 per cent level for these economies. It therefore seems reasonable to distinguish three cases :

- (i) *NWR* - *NWR\** :  $\zeta = \zeta^* = k = 0$ ,  $\dot{w} = \dot{m}$ ,  $\dot{w}^* = \dot{m}^*$ ,  $\bar{\beta}_1 = \bar{\beta}_1^* \rightarrow \infty$ ,  
 $\bar{\beta}_2 = 0$ ;
- (ii) *RWR* - *RWR\** :  $\zeta = \zeta^* = \infty$ ,  $k = 0$ ,  $w = p_c$ ,  $w^* = p_c^*$ ,  $\bar{\beta}_1 = \bar{\beta}_1^*$ ,  
 $\bar{\beta}_2 = 0$ ;
- (iii) *RWR* - *NWR\** :  $\zeta = \infty$ ,  $k = 0$ ,  $w = p_c$ ,  $\zeta^* = 0$ ,  $w^* = \dot{m}^*$ ,  $\bar{\beta}_1^* \rightarrow \infty$ .

The effects of unemployment on growth in real wages is ignored. Case (i) corresponds most closely to the conventional Mundell-Fleming world and describes the interdependence between, say, the US and Canadian economies (see Section 4). Core inflation is simply equal to the long-run monetary growth rate. Case (ii) describes the interdependence between, say, the French and German economies (see Section 5).<sup>7</sup> Case (iii) allows for real wage rigidity at home and nominal wage rigidity abroad and describes the interactions between, say, the US and European economies (see Section 6).

#### IV. NOMINAL WAGE RIGIDITY AT HOME AND ABROAD : A MUNDELL - FLEMING WORLD

##### IV.1 *Spill-over Effects of Fiscal, Monetary and Supply-side Policies*

The case of nominal wage rigidity at home and abroad corresponds most closely to the standard Mundell-Flemming analysis. It is well known that in such a world monetary expansion is a beggar-thy-neighbour policy whilst fiscal expansion is a locomotive policy. The purpose of this section is to examine whether these results carry through when the conventional two-country analysis is extended to allow for aggregate supply and expectational dynamics (cf., Turnovsky, 1985), to analyse the nature of the spill-over effects of supply-side policy, and to develop a convenient diagrammatic exposition that can be used for teaching purposes.

The assumption of  $\bar{\beta}_1 \rightarrow \infty$  makes matters simple, since the aggregate-supply schedule is replaced by the constant mark-up hypothesis,  $p = w + \tau$ .

7. Strictly speaking, this does not correspond to an economic model of the interdependence between the French and German economies as the salient features of the European Monetary System have been ignored. Managed intervention in the foreign exchange markets and restricted capital flows also are important in a two-country model of the French and German economies (e.g., Artis and Gazioglu, 1987).



Hence, the nominal interest rate is given by  $i = r + \dot{m} + \dot{\tau} + a\dot{E}c$  as wage inflation under *NWR* is simply given by  $\dot{w} = \dot{m}$ . Upon substitution into (3.6), one obtains the reduced form *LM*-schedule,

$$y = [\lambda(r + \dot{m} + \dot{\tau} + a\dot{E}c) - \tau] / \varphi. \quad (4.1)$$

It slopes upwards in  $r - y$  space (see Figure 1), because a higher interest rate chokes off money demand so that a higher level of national income is needed to restore equilibrium in the money market. In the general case (finite  $\bar{\beta}_1$ ), the interpretation is as follows. A higher real interest rate leads to an excess supply of money and thus to a higher price level. This reduces the supply of goods, since workers are locked into nominal wage contracts. Equation (4.1) gives aggregate supply, which should match aggregate demand given by equation (3.18). The result is equilibrium in the goods market, which is captured by the *GME*-locus :

$$r = [f + \gamma f^* + \delta c + [(\gamma\eta) - (\lambda\alpha/\varphi)] E\dot{c} - (\lambda/\varphi)(\dot{m} + \dot{\tau}) + (\tau/\varphi)] / [\sigma + (\lambda/\varphi)]. \quad (4.2)$$

Similarly, the *GME\**-locus follows from equations (3.7) and (3.19) and is given by :

$$r = [f^* + \gamma f - \delta c + [\eta + (\lambda(1 - \alpha)/\varphi)] E\dot{c} - (\lambda/\varphi)(\dot{m}^* + \dot{\tau}^*) + (\tau^*/\varphi)] / [\sigma + (\lambda/\varphi)]. \quad (4.3)$$

The *GME*-locus slopes upwards in  $r - c$  space (see Figure 1), because a higher interest rate increases the supply and reduces the demand for home goods and goods market equilibrium is then restored by an increase in net exports achieved by an increase in the relative price of foreign goods. Similarly, the *GME\**-locus slopes downwards in  $r - c$  space.

The equilibrium world interest rate follows from adding (4.2) and (4.3) :

$$r = 1/2[(1 + \gamma)(f + f^* + \bar{\eta}E\dot{c}) - (\lambda/\varphi)(\dot{m} + \dot{m}^* + \dot{\tau} + \dot{\tau}^*) + (\tau + \tau^*)/\varphi] / [\sigma + E\lambda/\varphi] \quad (4.4)$$

where  $\eta \equiv (1 - 2\alpha)[\sigma(1 - \gamma)^{-1} + (\lambda/\varphi)](1 + \gamma)^{-1} > 0$ . The steady-state world real interest rate decreases when budget deficits at home or abroad decrease, when monetary growth rates at home or abroad increase (the "Mundell effect"), and when reduction in tax rates boost the real supply of money balances.

Subtraction of (4.3) from (4.2) gives the following expression for the expectational dynamics of the real exchange rate :

$$\dot{E}c = [(1 - \gamma)(f - f^*) - (\lambda/\varphi)(\dot{m} - \dot{m}^* + \dot{\tau} - \dot{\tau}^*) + \varphi^{-1}(\tau - \tau^*) + 2\delta c] / [(1 - \gamma)\eta + (\lambda/\varphi)]. \quad (4.5)$$

The steady-state relative price of foreign goods increases when public deficits (or tax rates) abroad are higher than public deficits (or tax rates) at home, and when monetary growth exceeds foreign monetary growth. The real exchange rate jumps immediately to its new equilibrium value when shocks are permanent and unanticipated, but transient or anticipated shocks lead to expectational dynamics (see for example Figure 2(b) and the associated discussion in Section 5.1). Real liquidities,  $m - w$  and  $m^* - w^*$ , are constant, due to the assumption of  $\zeta = \zeta^* = k = 0$ , and therefore the adjustment to permanent and unanticipated shocks is instantaneous. Previous studies (e.g., Turnovsky, 1985) allowed for an effect of unemployment on growth in nominal wages ( $k \neq 0$ ), so that the steady-state level of output is always at its natural rate and unaffected by fiscal or monetary policy. This is not so in the present model, since it is concerned with the intermediate run.

The effects of an unanticipated, permanent increase in the home public deficit are presented in Figure 1(a). The resulting excess demand for home goods is choked off by an appreciation of the home real exchange rate and an increase in the world interest rate. The increase in the demand for foreign goods is due to the depreciation of the foreign real exchange rate, but despite

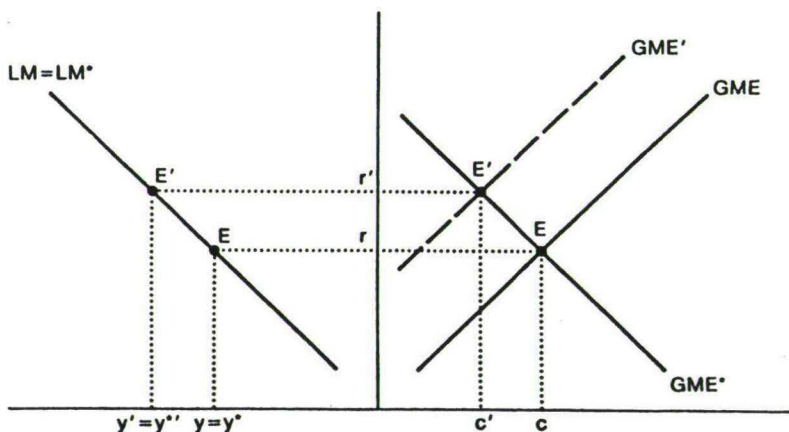


FIGURE 1(a). Wage Rigidity at Home and Abroad (Unanticipated increase in  $f$ )

the increase in the world interest rate. Supply at home and abroad increases, because the reduction in the demand for real cash balances boosts the price level and erodes the real value of the nominal wage. It follows that fiscal policy is a *locomotive* policy.

The effects of an unanticipated, permanent increase in the home monetary growth are presented in Figure 1(b). The expected inflation rate increases one-for-one, which reduces the world real interest rate ("Mundell effect") and therefore increases aggregate demand at home and abroad. The home nominal interest rate increases whilst the foreign nominal interest rate decreases, so that the demand for real money balances at home decreases, the home price level rises and home aggregate supply is boosted whilst foreign aggregate supply falls. The resulting excess demand for foreign goods is choked off by an increase in the relative price of foreign goods. Clearly, an expansion of monetary growth is a *beggars-thy-neighbour* policy. Figure 1(b) is also relevant

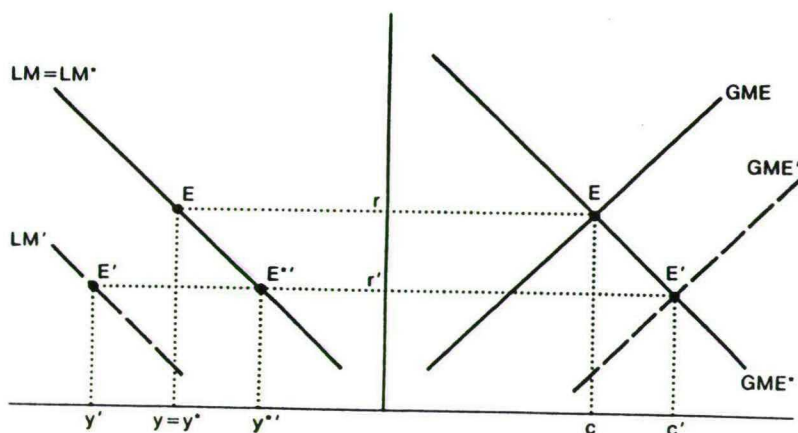


FIGURE 1(b). Nominal Wage Rigidity at Home and Abroad (Unanticipated increase in  $m$  or cut in  $\tau$ )

for an unanticipated, permanent tax incentive, so that supply-side improvements also have negative spill-over effects in a *NWR - NWR\** world. The reason is that a cut in the employers' tax rate, reduces the price level and boosts the real supply of money balances, which has the same effects as the cut in the real demand for money balances induced by an increase in monetary growth.

So far, it has been argued that, in a Mundell-Fleming world with nominal

wage rigidity at home and abroad, monetary expansion is a beggar-thy-neighbour policy. However, some argue that monetary expansion is a locomotive policy (e.g., Minford, 1985). The reason for this is that in the former case one is concerned with a bond-financed monetary expansion, i.e., the government purchases bonds from the private sector, whilst in the latter case a monetary expansion is associated with a looser fiscal stance, i.e., lower taxes or higher government spending. If one ignores interest payments on the public debt, the government budget constraint for the latter case is given by  $\log(\dot{m}) = f - (m - p)$  or, under *NWR*, by  $\log(\dot{m}) = f + \tau$  so that a change in monetary growth leads to a change in fiscal change ( $df = d\dot{m}/\dot{m}$ ). In empirical work the locomotive effects of the associated fiscal expansion seem to outweigh the beggar-thy-neighbour effects of the expansion in monetary growth (Minford, 1985).

A joint fiscal expansion shifts up both the *GME*- and the *GME\**-locus, so pushes up the world real interest rate and leaves the real exchange rate unaffected. The resulting fall in the demand for real money balances in each country generates an expansion of employment and output throughout the world. A joint increase in monetary growth has no effect on the real exchange rate, but reduces the world real interest rate and increases nominal interest rates and global activity. A joint improvement in supply-side conditions has similar effects.

An anticipated, permanent increase in the home fiscal deficit leads to an immediate jump appreciation of the real exchange rate followed by further appreciations during the announcement period (see Figure 2(b)). At the time of implementation there is no jump in the real exchange rate, because the news has already been discounted in the financial markets. The result is that home output and employment fall on impact of the news and fall further during the announcement period, whilst foreign output and employment increase on impact and increase further during the announcement period. At the time of implementation, the real interest rate and home output jump up. Hence, an anticipated increase in home demand leads to a current recession at home and boom abroad.

#### IV.2 *International Coordination of Monetary Policies*

In a *NWR* – *NWR\** world, monetary growth, fiscal expansion and supply-side improvements are, respectively, a beggar-thy-neighbour, locomotive and beggar-thy-neighbour policy, so that in the absence of international policy coordination these policies are, respectively, too expansionary, too tight and too far-reaching. To illustrate these issues, this section concentrates

on the determination of (bond-financed) monetary growth when the public deficit and supply-side policies are kept constant (say,  $\tau = \tau^* = f = f^* = 0$ ). There is a recent literature on the international coordination of monetary policies (Miller and Salmon, 1985; Currie and Levine, 1985; Oudiz and Sachs, 1985; and Rogoff 1985), but this literature typically relies on numerical simulation to assess the potential merits of policy coordination. Also, it incorporates the natural rate hypothesis so that there is no long-run trade-off between inflation and output. The present analysis is for the intermediate run and does allow for such a trade-off. To keep matters simple, the share of imports in final expenditures is assumed to be 50 per cent ( $\alpha = 1/2$ ). In such a world  $\dot{p} = \dot{w} = \dot{m}$ ,

$$\dot{p}_c = \dot{m} + 1/2 E\dot{c} = 1/2 (\dot{m} + \dot{m}^*) + (\delta\varphi/\lambda)c, \quad (4.6)$$

$$r = r^* = -1/2 \lambda(\sigma\varphi + \lambda)^{-1} (\dot{m} + \dot{m}^*), \quad (4.7)$$

$$y = \lambda\varphi^{-1}(r + \dot{m} + 1/2 E\dot{c}) = \delta c + \varepsilon(\dot{m} + \dot{m}^*) \quad (4.8)$$

and

$$E\dot{c} = \dot{m}^* - \dot{m} + (2\delta\varphi/\lambda)c, \quad \varepsilon \equiv 1/2 \tau\lambda(\tau\varphi + \lambda)^{-1} > 0 \quad (4.9)$$

where  $\varepsilon = 1/2\lambda(\sigma\varphi + \lambda)^{-1} > 0$ . A joint increase in monetary growth increases world inflation one-for-one and expands global activity.

The policy dilemma of each government is that it wants a high monetary growth rate in order to achieve a high level of activity and that it wants a low monetary growth rate in order to achieve low inflation. For the home government, this is captured by the following social welfare problem :

$$\text{Min}_{\dot{m}} 1/2 \int_0^{\infty} [\psi(y - \bar{y})^2 + \dot{p}_c^2] \exp(-\rho t) dt, \quad \psi, y, \rho, \geq 0, \quad (4.10)$$

subject to (4.6) - (4.9), where  $\psi$ ,  $\bar{y}$  and  $\rho$  denote the relative priority attached to achieving the full-employment target, the full-employment (desired) target of home activity and the social rate of time preference, respectively. The policy dilemma is that a policy of no inflation leads to a too low level of activity ( $\bar{y} > 0$ ). The home country's social welfare problem can be rewritten as :

$$\text{Min}_{\dot{m}} 1/2 \int_0^{\infty} [\psi [\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}]^2 + [1/2(\dot{m} + \dot{m}^*) + (\delta\varphi/\lambda)c]^2] \exp(-\rho t) dt \quad (4.11)$$

subject to (4.9). The foreign country's social welfare problem can be written as:

$$\text{Min}_{\dot{m}^*} \frac{1}{2} \int_0^{\infty} [\psi[-\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}]^2 + \frac{1}{2}[\frac{1}{2}(\dot{m} + \dot{m}^*) - (\delta\varphi/\lambda)c]^2] \exp(-\rho t) dt \quad (4.12)$$

subject to (4.9), where the foreign government is assumed to have the same preferences as the home government.

When the two governments decide on their optimal monetary policies in a decentralised fashion and when they cannot pre-commit themselves to these policies vis-à-vis the private sector, the (open-loop) Nash equilibrium with pre-commitment is the appropriate solution concept. The relevant first-order conditions are:

$$\psi\varepsilon[\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}] + \frac{1}{2}[\frac{1}{2}(\dot{m} + \dot{m}^*) + (\delta\varphi/\lambda)c] - x = 0 \quad (4.13)$$

$$\psi\varepsilon[-\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}] + \frac{1}{2}[\frac{1}{2}(\dot{m} + \dot{m}^*) - (\delta\varphi/\lambda)c] + x^* = 0 \quad (4.14)$$

$$\begin{aligned} \dot{x} = & [\rho - 2(\delta\varphi/\lambda)] x^* - \psi\delta[-\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}] \\ & - (\delta\varphi/\lambda)[\frac{1}{2}(\dot{m} + \dot{m}^*) + (\delta\varphi/\lambda)c], \quad x(0) = 0 \end{aligned} \quad (4.15)$$

$$\begin{aligned} \dot{x}^* = & [\rho - 2(\delta\varphi/\lambda)] x^* + \psi\delta[-\delta c + \varepsilon(\dot{m} + \dot{m}^*) - \bar{y}] \\ & + (\delta\varphi/\lambda)[\frac{1}{2}(\dot{m} + \dot{m}^*) - (\delta\varphi/\lambda)c], \quad x^*(0) = 0 \end{aligned} \quad (4.16)$$

where  $x(x^*)$  denotes the undiscounted shadow price of the real exchange rate to the home (foreign) government. At the beginning of the planning horizon, the real exchange rate is free to jump and therefore its contribution to social welfare at that time must be zero (cf., Calvo, 1978);  $x(0) = x^*(0) = 0$ . Subtraction of (4.14) and (4.13) and addition of (4.15) and (4.16) yields  $x(t) + x^*(t) = c(t) = 0$ , for all  $t \geq 0$ . Equation (4.9) then gives  $\dot{m} = \dot{m}^*$ , so that  $y = y^* = 2\varepsilon m$  and  $\dot{p} = \dot{p}^* = \dot{m}$ . Addition of (4.13) and (4.14) then gives

$$x - x^* = \frac{1}{2}(1 + 4\psi\varepsilon^2)(\dot{m} + \dot{m}^*) - 2\psi\varepsilon\bar{y}, \quad (4.17)$$

so that subtraction of (4.16) from (4.15) yields

$$\begin{aligned} \ddot{m} = & [\rho - 4(1 + 4\psi\varepsilon^2)^{-1}[(\delta\varphi/\lambda) + \psi\delta c(1 + 2\varepsilon\varphi)]]\dot{m} + 2\psi(1 + 4\psi\varepsilon^2)^{-1} \\ & [\delta - [\rho - 2(\delta\varphi/\lambda)]\varepsilon]\bar{y}, \quad \dot{m}(0) = 2\psi\varepsilon(1 + 4\psi\varepsilon^2)^{-1}\bar{y} \equiv \dot{m}_c. \end{aligned} \quad (4.18)$$

The solution of (4.18) is given by

$$\dot{m}(t) = \dot{m}^*(t) = \dot{m}_N + (\dot{m}_C - \dot{m}_N) \exp(-\lambda_N t), \quad (4.19)$$

where the steady-state Nash equilibrium value of monetary growth is given by

$$\dot{m}_N = 2\psi(1 + 4\psi\epsilon^2)^{-1} [\delta - [\rho - 2(\delta\phi/\lambda)]\epsilon] \bar{y} / \lambda_N \quad (4.20)$$

and the speed of policy adjustment under decentralised policy making is given by

$$\lambda_N = 4(1 + 4\psi\epsilon^2)^{-1} [(\delta\phi/\lambda) + \psi\delta\epsilon(1 + 2\epsilon\phi)] - \rho > 0. \quad (4.21)$$

The outcome under international coordination of monetary policies and pre-commitment is obtained by choosing  $\dot{m}$  and  $\dot{m}^*$  to minimise the sum of the two countries' welfare loss functions subject to (4.9). This yields  $c(t) = 0$ ,  $\dot{p}_C(t) = \dot{m}(t) = \dot{m}_C$ ,  $y(t) = y^*(t) = 2\epsilon\dot{m}_C$  and  $r(t) = r^*(t) = -2\lambda(\sigma\phi + \lambda)^{-1}\dot{m}_C$ , for all  $t \geq 0$  as the outcomes under international policy coordination.

It can easily be shown that the inequality  $\dot{m}_N > \dot{m}_C$  holds, so that the monetary growth rates that prevail in the absence of international policy coordination are excessive. This is due to the fact that an increase in monetary growth is a beggar-thy-neighbour policy and that each government ignores the adverse consequences of such a policy on the rival government. The optimal non-cooperative policies are time inconsistent (Kydland and Prescott, 1977), since if a government reneges and re-optimises at a later date it pays to reduce monetary growth again to its cooperative level and subsequently raise it gradually to its non cooperative level. The "loss of leadership" solution (Buiter, 1984) is an open-loop, time-consistent Nash equilibrium solution, since it assumes that the governments ignore, or do not manipulate, the forward-looking component of the real exchange rate. This means that  $x(t) = x^*(t) = 0$ , for all  $t \geq 0$ , instead of (4.15)–(4.16), so that  $\dot{m}(t) = \dot{m}^*(t) = \dot{m}_C$  is the competitive, time-consistent outcome. The cooperative outcome is time consistent, so that when governments cannot pre-commit there is no gain from international policy coordination. In fact, when the governments cannot pre-commit and the economies eventually return to their natural rates ( $k > 0$ ), international policy coordination is only a transient issue and can be counter-productive (Rogoff, 1985).<sup>8</sup>

8. When the time inconsistency of optimal monetary policies arises in the form of a surprise inflation tax, it can be shown that international coordination can also be counter-productive when governments cannot pre-commit themselves (van der Ploeg, 1988).

## V. REAL WAGE RIGIDITY AT HOME AND ABROAD

### V.1 *Spill-over Effects of Fiscal and Supply-side Policies*

Now consider case (ii), which assumes real wage rigidity at home and abroad. This might characterise economic interdependence within Europe. Substitution of  $w = p_c$ , (3.5) and (3.9) into (3.11) yields the *AS*-schedule :

$$y = -\bar{\beta}_1(\alpha c + \tau) + \bar{\beta}_3. \quad (5.1)$$

Aggregate supply increases whenever the wedge between the producers' wage and the consumers' wage, i.e.,  $\alpha c + \tau$ ,<sup>9</sup> decreases. Hence, when the real exchange rate depreciates, the cost-of-living for workers and therefore their wage claim increases so that firms employ less labour and produce less output.<sup>10</sup> Similarly, an increase in the employers' tax rate reduces incentives to employ labour and produce output. Both the home and foreign *AS*-schedules are drawn in the bottom half of Figure 2(a).

Intersection of the *AD*-schedule (3.18), and the *AS*-schedule (5.1), yields equilibrium in the home goods market. This gives rise to the *GME*-locus.

$$r = [f + \gamma f^* + \bar{\beta}_1 \tau - \bar{\beta}_3 + (\delta + \alpha \bar{\beta}_1)c + \gamma \eta \dot{E}c] / \sigma \quad (5.2)$$

and, similarly, to the *GME\**-locus

$$r = [f^* + \gamma f + \bar{\beta}_1 \tau^* - \bar{\beta}_3^* - (\delta + \alpha \bar{\beta}_1)c + \eta \dot{E}c] / \sigma \quad (5.3)$$

(see Figure 2(a)). The *GME*-locus slopes upwards, because the excess supply of goods induced by a rise in the real interest rate is choked off by a depreciation of the real exchange rate which boosts net exports and cuts aggregate supply. Intersection of the *GME*-locus and the *GME\**-locus yields the relative price of foreign goods in terms of home goods :

$$c = 1/2[(1 - \gamma)(f^* - f + \eta \dot{E}c) + \bar{\beta}_1(\tau^* - \tau) + \bar{\beta}_3 - \bar{\beta}_3^*] / (\delta + \alpha \bar{\beta}_1). \quad (5.4)$$

The real interest rate and output then follow upon substitution of (5.4) into

9. In general, one should also add the employees' tax rate and the indirect tax rate to the wedge.

10. Note that, in contrast to Branson and Rotemberg (1980), aggregate supply never rises when the real exchange rate depreciates (thus excluding their example of the Hong Kong economy).





(5.2) and (5.1). Alternatively, the comparative statics can be deduced from Figure 2(a).

An unanticipated permanent fiscal expansion at home shifts up the *GME*-locus by more than the *GME\**-locus, so that the incipient excess demand for goods is choked off by a rise in the world real interest rate and a fall in the relative price of home goods. The real appreciation of the home currency occurs instantaneously. It reduces the wedge and increases aggregate supply at home, but increases the wedge and reduces aggregate supply abroad. The boost in foreign aggregate demand, due to the real depreciation of the foreign exchange rate and the increase in home activity, and the fall in foreign aggregate supply must be choked off by the rise in the world real interest rate. Clearly, fiscal expansion is a *beggar-thy-neighbour* policy in a *RWR-RWR\** world. This contrasts with a *NWR-NWR\** (Mundell-Fleming) world, where fiscal expansion is a locomotive policy (see Section 4). The fall in foreign output and the increase in the world interest rate reduces the demand for real foreign money balances, so that the foreign price level must increase. The effect on the home price level is ambiguous. Note that, under purchasing power parity ( $\delta \rightarrow \infty$ ), neither home nor fiscal policy can affect the wedge and consequently output and employment.

The expectational dynamics can be deduced from Figure 2(b). An anticipated permanent fiscal expansion at home leads to a jump appreciation of the real exchange rate and thus to an immediate expansion of home activity and fall in foreign activity. The real exchange rate is expected to appreciate, so that there is a real-interest-rate differential in favour of the home country during the announcement period *AB*. The *GME\**-locus shifts down more than the *GME*-locus, so that the home real interest rate falls during the announcement period. This generates the extra demand to choke off the excess supply of goods induced by the real appreciation of the exchange rate. Similarly, the foreign real interest rate must increase during the adjustment period. Obviously, during the adjustment period, home activity continues to increase and foreign activity continues to fall. At the time of implementation of the home fiscal expansion, there is no jump in the real exchange rate and no change in home or foreign activity as the fiscal expansion has already been discounted in the financial markets. Instead, there is an implementation effect leading to an upward jump in the world real interest rate which completely crowds out the increase in demand caused by the fiscal expansion. Since the home real interest rate rises above its original equilibrium value, it is clear that it *misadjusts* when there is an anticipated fiscal expansion.

An unanticipated permanent improvement in home supply, due to a cut in the home tax rate or an increase in home productivity, shifts down the

*GME*-locus and shifts out the *AS*-schedule. The increase in home supply is partially accommodated by the increase in demand due to the fall in the world real interest rate and the depreciation of the real exchange rate, but obviously the latter effect increases the home wedge and crowds out some of the initial increase in home supply. The counter-part of this is that the foreign wedge falls and thus foreign activity increases. Foreign demand increases due to the fall in the world interest rate and despite the improvement in foreign net

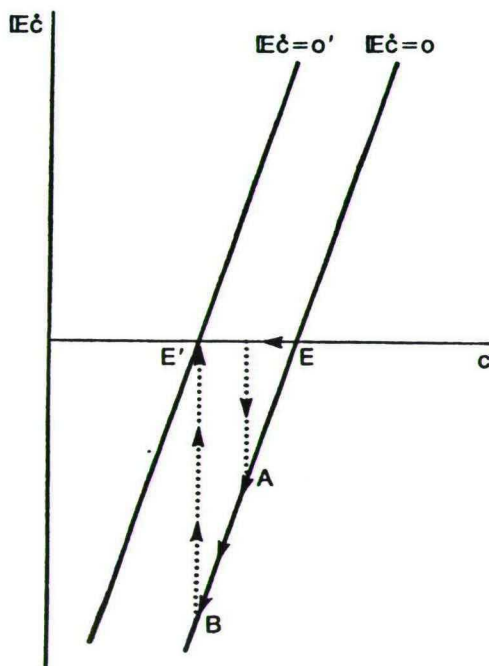


FIGURE 2(b). Real Wage Rigidity at Home and Abroad (Anticipated increase in  $f$ )

exports. Hence, supply-side improvements are a *locomotive* policy in a *RWR-RWR\** world.

A joint fiscal expansion or a joint improvement in supply-side conditions has no real effects whatsoever in this symmetric two-country world, although it does increase world interest rates and reduce price levels. This is in contrast to the effects in a *NWR-NWR\** world (see Section 4.1). A monetary expansion, either at home or abroad, has no real effects in a *RWR-RWR\** world.

Due to full indexation of wages to the cost-of-living index, a unilateral monetary expansion leads to a one-for-one increase in the home price level, a one-for-one depreciation of the nominal exchange rate and no effect on output and employment. However, if the model is extended to allow for investment and capital accumulation, an interdependent Mundell-Tobin effect emerges. An increase in home monetary growth reduces the world real interest rate and therefore increases capital, employment and output both at home and abroad, so that it is a locomotive policy (van der Ploeg, 1986).

It follows that fully indexed economies are insulated from monetary shocks, but are more responsive to real supply-side (say, tax or oil) shocks.

Finally, it may be useful to consider the special case of perfect substitution between home and foreign goods, i.e., purchasing power parity ( $\delta \rightarrow \infty$ ). In that case, the real exchange rate and the wedge between the producers' and consumers' wage are fixed so that output at home and abroad are unaffected by fiscal or supply-side policies (see equations (5.1) and (5.4)).

## V.2 International Coordination of Fiscal Policy

In a *RWR-RWR\** world monetary growth directly affects inflation and has neither a transient nor a persistent effect on real activity. A fiscal expansion at home benefits activity at home and reduces activity abroad. The adverse effects of a fiscal expansion are higher budget deficits, which to the extent that they are financed by an increase in monetary growth have an adverse effect on inflation. The policy dilemma of each country is that they want a high level of government spending for high activity, but a low level of government spending for low inflation. These are exercises in the optimal determination of fiscal policy, so that the effects of supply-side policies are suppressed ( $\tau = \tau^* = \bar{\beta}_3 = \bar{\beta}_3^* = 0$ ). The policy dilemma of the home country is captured by the following social welfare problem :

$$\text{Min}_f \int_0^{\infty} [\bar{\psi}(y - \bar{y})^2 + f^2] \exp(-\rho t) dt, \quad \bar{\psi}, \bar{y}, \rho \geq 0, \quad (5.5)$$

subject to (5.1) and (5.4), where  $\bar{\psi}$  is the relative priority attached to achieving the full-employment target,  $\bar{y}$  is the full-employment (desired) level of home activity, and  $\rho$  is the government's rate of time preference. The policy dilemma is that a balanced budget or a budget consistent with no inflation leads to a too low level of activity and that achievement of the full-employment target leads to excessive government deficits and inflation. The home country's welfare problem can be rewritten as :

$$\text{Min } \frac{1}{2} \int_0^{\infty} [\psi(c + \bar{c})^2 + f^2] \exp(-\rho t) dt, \quad \psi, \bar{c} \geq 0 \quad (5.6)$$

subject to

$$E\dot{c} = (\Gamma c + f - f^*)/\eta, \quad c(0) = \text{free} \quad (5.7)$$

where  $\psi \equiv \bar{\psi}(\beta_1 \alpha)^2$ ,  $\bar{c} \equiv \bar{y}/(\beta_1 \alpha)$  and  $\Gamma \equiv 2(\delta + \bar{\beta}_1 \alpha)/(1 - \gamma)$  (assumed to exceed  $\eta\rho$ ). The foreign country faces a similar welfare problem:

$$\text{Min } \frac{1}{2} \int_0^{\infty} [\psi^*(c - \bar{c})^2 + f^{*2}] \exp(-\rho t) dt, \quad \psi^* \geq 0 \quad (5.8)$$

subject to (5.7), where allowance has been made for the possibility that the two countries may attach different priorities to achieving the full-employment target.

When the governments of the two countries can pre-commit and decide on their optimal fiscal policies in a competitive fashion, the Nash equilibrium with pre-commitment is the appropriate solution concept. The relevant first-order conditions can be written as:

$$\dot{f} = -[(\Gamma/\eta) - \rho]f + (\psi/\eta)(c + \bar{c}), \quad f(0) = 0, \quad (5.9)$$

$$\dot{f}^* = -[(\Gamma/\eta) - \rho]f^* - (\psi^*/\eta)(c - \bar{c}), \quad f^*(0) = 0, \quad (5.10)$$

and (5.7), where the adjoint variable associated with the real exchange rate for the home (foreign) country is given by  $-\eta f$  ( $\eta f^*$ ). Since the real exchange rate is free to jump at time zero, its marginal contribution to social welfare at that time must be zero (cf., Calvo, 1978) and therefore  $f(0) = f^*(0) = 0$  must hold. It follows from subtraction of (5.10) from (5.9) and from (5.7) that, when  $\psi = \psi^*$ ,  $c(t) = y(t) = y^*(t) = f(t) - f^*(t) = 0$ , for  $t \geq 0$ , so that  $r(t) = r^*(t) = (1 + \gamma)f(t)/\sigma$  and

$$f(t) = f^*(t) = f_N \{1 - \exp[-(\Gamma/\eta) - \rho]t\}, \quad f_N \equiv \psi \bar{c} / (\Gamma - \eta\rho). \quad (5.11)$$

Note that, when the share of imported goods in total expenditures is 50 per cent, the adjustment to the steady-state Nash equilibrium levels of public spending is instantaneous ( $f(t) = f^*(t) = f_N$ , for  $t > 0$ , when  $\alpha = 1/2$ ). In general ( $\alpha < 1/2$ ), the levels of public deficits are at their no-inflation levels at the start of the planning horizon and afterwards gradually increase towards their steady-state Nash equilibrium levels. This means that the optimal levels

of public deficits in the Nash equilibrium with pre-commitment are time inconsistent; when the governments re-optimize after some time they will want to tighten their fiscal policies back to the no-inflation levels.

When the governments of the two countries engage in international policy coordination with pre-commitment, they minimise the global welfare loss and take account of the constraint that the real exchange rate and therefore activity cannot be affected. Hence, when  $\psi = \psi^*$ ,  $c(t) = y(t) = y^*(t) = r(t) = r^*(t) = f(t) = f^*(t) = 0$ ,  $t \geq 0$ , are the cooperative outcomes. There is no problem of time inconsistency when international policy coordination takes place.

The non-cooperative outcomes lead to excessive levels of public deficits relative to the cooperative outcomes. This is a consequence of the beggar-thy-neighbour nature of fiscal policies in a *RWR-RWR\** world, since in the non-cooperative outcomes each government ignores the adverse consequences of a fiscal expansion on the other economy. In effect, each country attempts (in vain) to have a high real exchange rate in order to boost employment at home and export unemployment and this is what leads to excessive public deficits. The cooperative outcomes realise the futility of such actions and increase welfare by setting the public deficits at their no-inflation levels. The inefficiencies of the non-cooperative outcomes increase when the priorities attached to achieving the full-employment targets increase, when the desired levels of activity increase, and when the governments' discount rates increase.

When the home country (say, France) attaches a higher priority to the employment target than the foreign country (say, Germany), the steady-state Nash equilibrium levels of the real exchange rate and the fiscal deficit are given by:

$$c_N = (\psi^* - \psi)\bar{c} / [(\Gamma - \eta\rho)\Gamma + \psi + \psi^*] < 0 \quad (5.12)$$

$$f_N = \psi[2\psi^* + (\Gamma - \eta\rho)\Gamma] \bar{c} / \{(\Gamma - \rho\eta)[(\Gamma - \eta\rho)\Gamma + \psi + \psi^*]\} > 0 \quad (5.13)$$

so that  $y_N > 0 > y_N^*$  and  $f_N > f_N^* > 0$ . The country that attaches a higher priority to achieving full employment ends up with a higher level of activity, at the expense of a lower level of activity in the other economy, and a higher level of the public deficit and inflation.

As far as supply-side improvements are concerned, they are a locomotive policy in a *RWR-RWR\** world. It is clear that, in the absence of international policy coordination, supply-side improvements do not go far enough as each country ignores the beneficial effects on the other country.

It may be useful to relate the analysis of this section to the pioneering

work of Hamada (1985, Chapter 5) on the international coordination of monetary policies. Although Hamada was concerned with a full-employment multi-country world, the international trade-offs for monetary policies are similar in a *RWR-RWR\** world. Consider the case of floating exchange rates first. Monetary growth has no real effects, so that each country sets its optimal monetary growth to its desired rate of inflation. Since the monetary authorities do not face a policy trade-off, there is no role for international policy coordination. Now consider the case of pegged exchange rates ( $\epsilon = 0$ ). Increases in monetary growth ( $\dot{m}$ ) are either due to increases in the rate of domestic credit expansion ( $\dot{d}$ ) or due to balance-of-payments surpluses, expressed as a ratio of the money supply ( $z$ ). The monetary approach to the balance of payments then gives the balance-of-payments ratio of each country as the excess of the common inflation rate ( $\pi$ ) over its rate of domestic credit expansion, i.e.,  $z = \pi - \dot{d} = \pi_R + 1/2(\dot{d}^* - \dot{d})$ , where the ratio of the increase in international reserves to the world money supply is denoted by  $\pi_R$  and the world inflation rate is given by  $\pi \equiv \dot{p} = \dot{p}^* = \pi_R + 1/2(\dot{d} + \dot{d}^*)$ . Denote each country's desired inflation rate by  $\bar{\pi} = \bar{\pi}^*$  and desired balance of payments ratio by  $\bar{z}$ . Hamada shows that, in the absence of international policy coordination, world inflation ( $\pi$ ) is higher (lower) than desired inflation ( $\bar{\pi}$ ), when the increase in international reserves ( $\pi_R$ ) is larger (smaller) than the weighted averages of the desired increases in international reserves ( $1/2(\bar{z} + \bar{z}^*)$ ).

## VI. REAL WAGE RIGIDITY IN EUROPE AND NOMINAL WAGE RIGIDITY IN THE U.S.

### VI.1 *Asymmetries in International Interdependence*

The interactions between the European (home) and US (foreign) economies are best described by an asymmetric world, that is real wage rigidity is assumed for Europe (and Japan) and nominal wage rigidity for the US and Canada (see Section 2). In that case, the world real interest rate and the real exchange rate follow from the intersection of the *GME*-locus, (5.2), and the *GME\**-locus, (4.3), suitably modified to allow for the effects of imported raw materials. European output depends on the real exchange rate and follows from the *AS*-schedule,

$$y = -\bar{\beta}_1(\bar{ac} + \tau) + \bar{\beta}_3 \quad (6.1)$$

where  $\bar{\alpha} \equiv \alpha + \bar{\beta}_2$  and  $\bar{\beta}_3 \equiv \beta_3 - \bar{\beta}_1 \bar{\beta}_2 \dot{p}_n^*$ , whilst US output depends on the US interest rate and follows from the reduced-form  $LM^*$ -schedule,

$$y^* = [\lambda[r + \dot{m}^* + \dot{\tau}^* + \bar{\beta}_2 \dot{p}_n^* - (1 - \alpha)E\dot{c}] - \tau^* - \bar{\beta}_2 \dot{p}_n^*] / \varphi. \quad (6.2)$$

Hence, both European and US aggregate supply decrease when the price of oil (fixed in terms of US goods) increases. The  $AS$ -schedule is steeper than before, because a real depreciation of the European currency not only increases the wedge but also increases the real price of oil to Europe. The comparative statistics of unanticipated, permanent shocks can be deduced by diagrammatic means (see Figure 3). The equilibrium real interest rate is given by

$$\begin{aligned} r = & \{[\gamma(\delta + \bar{\alpha}\beta_1) + \delta]f + (\delta + \bar{\alpha}\beta_1 + \gamma\delta)f^* + \bar{\beta}_1\delta\tau \\ & + (\delta + \bar{\alpha}\beta_1)\varphi^{-1}(\tau^* + \bar{\beta}_2\dot{p}_n^*) - \lambda(\delta + \bar{\alpha}\beta_1)\varphi^{-1}(\dot{m}^* + \dot{\tau}^* + \bar{\beta}_2\dot{p}_n^*) - \delta\bar{\beta}_3 \\ & + [(\eta + \lambda(1 - \alpha)\varphi^{-1})(\delta + \bar{\alpha}\beta_1) + \gamma\eta\delta]E\dot{c}\} / \Delta \end{aligned} \quad (6.3)$$

and the equilibrium real exchange rate follows from

$$\begin{aligned} c = & \{-[(\sigma + \lambda/\varphi) - \gamma\sigma]f + [-(\sigma + \lambda/\varphi)\gamma + \sigma]f^* - \bar{\beta}_1(\sigma + \lambda/\varphi)\tau \\ & + \varphi^{-1}\sigma[\tau^* + \beta_2\dot{p}_n^* - \lambda(\dot{m}^* + \dot{\tau}^* + \bar{\beta}_2\dot{p}_n^*)] + (\sigma + \lambda/\varphi)\bar{\beta}_3 \\ & - [\gamma\eta(\sigma + \lambda/\varphi) - \sigma(\eta + \lambda\varphi^{-1}(1 - \alpha))]E\dot{c}\} / \Delta \end{aligned} \quad (6.4)$$

where  $\Delta \equiv (\sigma + \lambda\varphi^{-1})(\delta + \bar{\alpha}\beta_1) + \delta\sigma > 0$ . The real exchange rate, and consequently all other endogenous variables, jump instantaneously to their new equilibrium values in response to unanticipated permanent shocks, as long as the saddlepoint condition is satisfied ( $\sigma\lambda(1 - \alpha) + \sigma\eta\varphi(1 - \gamma) > \lambda\eta\gamma$ ), which is definitely the case for  $\alpha = 1/2$ . Figure 2(b) can be used to analyse the effects of anticipated, permanent shocks.

The effects of an unanticipated permanent increase in the European public deficit are presented in Figure 3(a). The excess demand for European goods is partially choked off by a fall in the relative price of US goods, which induces an increase in European supply and US demand and a fall in European demand for goods, and by a rise in the world interest rate, which induces a fall in the European and US demand for goods and an increase in the US supply of goods. The above is captured by the fact that the upward shift of the  $GME$ -locus dominates the upward shift of the  $GME^*$ -locus. It shows that a European fiscal expansion increases output and employment in both Europe



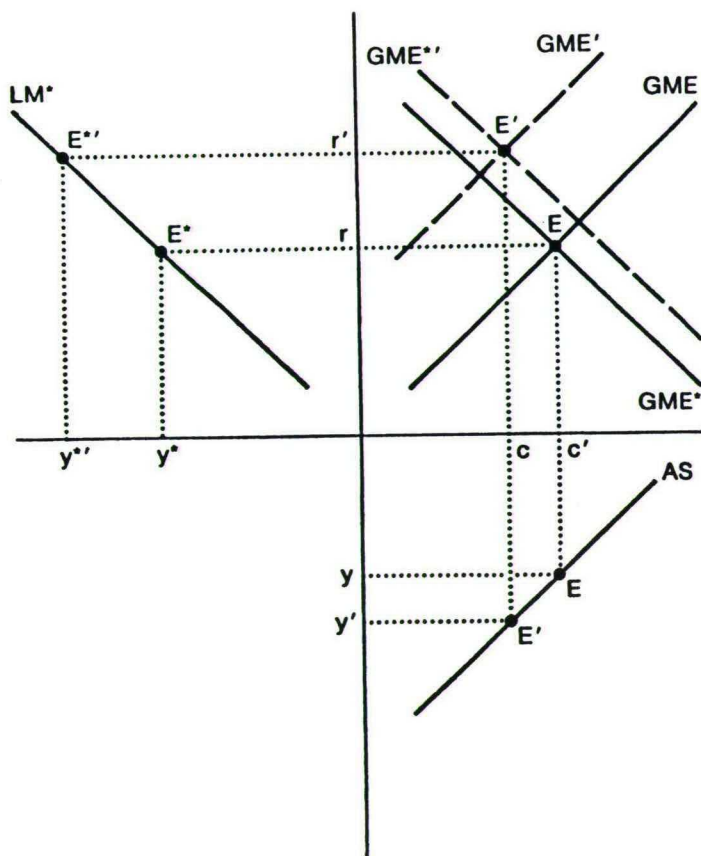


FIGURE 3(a). Interdependence of the European and US Economies (Unanticipated increase in the European public deficit)

and the US and is therefore a *locomotive* policy. For a US fiscal expansion, the shift in the  $GME^*$ -locus, typically (as long as  $\sigma(1 - \gamma)\phi > \lambda\gamma$ ), dominates the shift in the  $GME$ -locus and therefore results in a rise in the world interest rate and, typically, an increase in the relative price of US goods. Hence, a US fiscal expansion increases output in the US and, typically, leads to a depreciation of the European real exchange rate, an increase in the European wedge and therefore a reduction in European output. It is therefore, typically, a *beggar-thy-neighbour* policy. However, if the negative effects of financial

crowding out on European consumption and investment are not too important relative to the positive spill-over effects of US activity on European exports (if  $\bar{\sigma}\varphi/\lambda < \gamma$ ), a US fiscal expansion increases European output and employment and therefore is a *locomotive* policy. Plausible parameter values are  $\bar{\sigma} = 0.5$ ,  $\varphi = 1.0$ ,  $\lambda = 0.5$  and  $\gamma = 0.3$ , which suggests that a US fiscal expansion is a *beggar-thy-neighbour* policy. It will be assumed that this is the typical case.

An increase in European monetary growth has no real effects, because European wages are indexed to increases in the cost-of-living. It simply increases the European inflation and nominal interest rates one-for-one. The effects of an unanticipated, permanent increase in the US monetary growth rate are presented in Figure 3(b). It increases the US nominal interest rate, cuts US demand for real money balances, exerts an upward pressure on the US price level, erodes the real value of the US wage, and therefore increases US aggregate supply. This is partially accommodated by the increase in the demand for US goods due to a fall in the relative price of US goods and a fall in the US real interest rate. The associated appreciation of the European real exchange rate, reduces the wedge between the European consumers' and producers' wage, and therefore raises European supply. European demand rises due to the fall in the world real interest rate. Clearly, US monetary growth is a *locomotive* policy. A cut in the US tax rate also raises US aggregate supply and therefore raises output and employment in Europe as well as in the US. Hence, a US tax cut is a *locomotive* policy. A cut in the European tax rates shifts out the *AS*-schedule and shifts down the *GME*-locus, so that the real interest rate falls, the European real exchange rate appreciates and European output increases. US output falls, so supply-side improvements in Europe are a *beggar-thy-neighbour* policy.

An increase in the real price of oil (in terms of US goods) shifts in the *AS*- and *LM*\*-schedules and consequently shifts up the *GME*- and *GME*\*-loci. The fall in the world supply of goods induces a rise in the world real interest rate, which attenuates the adverse effects of the oil shock on US supply. The effect on the real exchange rate (and therefore on European output) is ambiguous, but, if  $\sigma > \beta_1(\sigma\varphi + \lambda)$ , the adverse effects on US supply dominate the adverse effects on European supply and then the relative price of US goods increases. In that case, the European real exchange rate depreciates and therefore the adverse effects of an oil shock on European supply are accentuated rather than attenuated. This therefore seems to suggest that an oil shock hits European output and employment much harder than US output and employment.

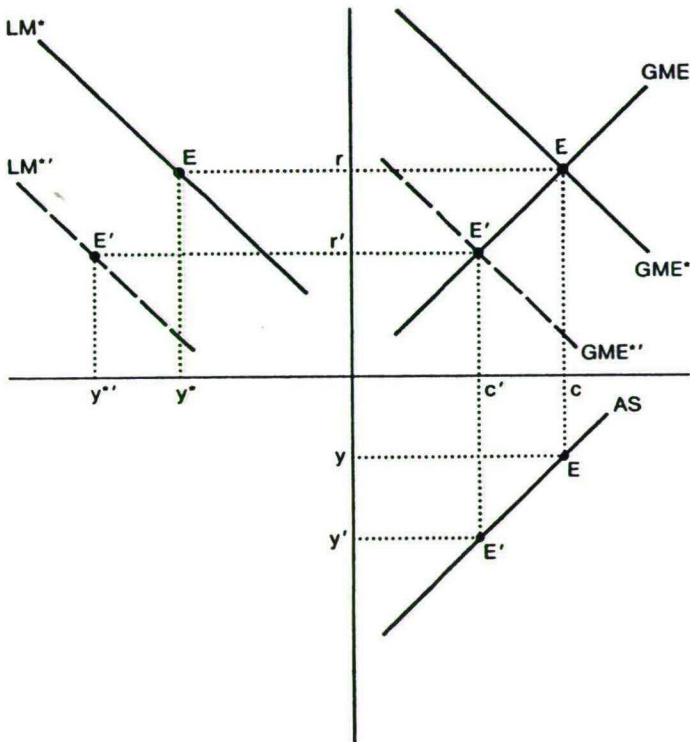


FIGURE 3(b). Interdependence of the European and US Economies (Unanticipated increase in US monetary growth or cut in the US tax rate)

### VI.2 *International Economic Policy Coordination*

Section 6.1 showed that a European fiscal expansion, an increase in US monetary growth and a US tax cut stimulate output at home and abroad. This means that, in the absence of international policy coordination, the US (Europe) ignores the beneficial effects on European (US) output and employment of an increase in monetary growth or a supply-side incentive (a fiscal expansion). Hence, the US has a too low monetary growth rate and does not offer enough supply-side improvements whilst Europe's fiscal stance is too tight relative to the outcomes under international policy coordination. Similarly, a cut in European employers' taxes and, typically, a US fiscal expansion have negative spill-over effects. This means that in the absence of internationa

policy coordination, European supply-side improvements are too far-reaching and US fiscal policy is, typically, too tight.

Now consider in detail the case of the optimal determination of the European and US public deficits when they are financed by bonds. The social welfare functions are given by (5.5), where after the OPEC shocks  $\bar{y} > \bar{y}^*$  as an oil price shock hits Europe harder than the US. The description of the European and US economies follows upon substitution of (6.4) and (6.3) into (6.1) and (6.2) and from (6.4):

$$y = \omega_1 f - \omega_2 f^* + \omega_3 \dot{m}^* - \omega_4 \dot{E}\dot{c}, \quad (6.5)$$

$$y^* = \omega_1^* f^* + \omega_2^* f + \omega_3^* \dot{m}^* - \omega_4^* \dot{E}\dot{c}, \quad (6.6)$$

$$\dot{E}\dot{c} = \omega_5 \dot{c} + \omega_6 f - \omega_7 f^* + \omega_8 \dot{m}^*, \quad (6.7)$$

where  $\omega_1 > 0$ ,  $\omega_i > 0$ ,  $i = 3, 8$ ,  $\omega_i^* > 0$ ,  $i = 1, 4$ ,  $\text{sign}(\omega_2) = \text{sign}(\omega_7)$  and  $\omega_5 > \rho$ . With the same procedure as used in Sections 4.2 and 5.2, one finds that in the absence of international policy coordination the optimal steady-state public deficits when governments can pre-commit themselves must satisfy:

$$f = -\psi(y - \bar{y}) = \psi(\omega_2 f^* + \bar{y}) / (1 + \psi\omega_1) \quad (6.8)$$

$$f^* = \psi^*(y^* - \bar{y}^*) = -\psi^*(\omega_2^* f - \bar{y}^*) / (1 + \psi^*\omega_1^*), \quad (6.9)$$

where  $\psi \equiv \bar{\psi} [\omega_1 + \rho\omega_4\omega_6(\omega_5 - \rho)^{-1}] > 0$  and  $\psi^* \equiv \bar{\psi} [\omega_1^* - \rho\omega_4^*\omega_7(\omega_5 - \rho)^{-1}] > 0$ . Both countries "lean against the wind", that is the public deficit is increased when output falls below its full-employment level. If Europe reduces its deficit, US output falls and therefore the US government reacts and increases its deficit. The European asymptotic reaction curve is upward- or downward-sloping depending on whether a US fiscal expansion is a beggar-thy-neighbour or a locomotive policy, respectively. If the positive spill-over effect of US activity on European exports is dominated by financial crowding out ( $\gamma < \bar{\sigma}\phi/\lambda$ ), a US fiscal expansion is a beggar-thy-neighbour policy ( $\omega_2 > 0$ ) and therefore Europe reacts with a fiscal expansion as well. The Nash equilibrium solution corresponds to the intersection of the reaction curves (6.8)-(6.9) and yields:

$$f = [(1 + \psi^*\omega_1^*) \psi \bar{y} + \psi \omega_2 \psi^* \bar{y}^*] / \Delta_N \equiv f_N \quad (6.10)$$

$$f^* = [-\psi^*\omega_2^* \psi \bar{y} + (1 + \psi\omega_1) \psi^* \bar{y}^*] / \Delta_N \equiv f_N^* \quad (6.11)$$

where  $\Delta_N \equiv (1 + \psi\omega_1)(1 + \psi^*\omega_1^*) + \psi\omega_2\psi^*\omega_2^* > 0$ . Note that, when the desired change in home output increases, each country increases its public sector deficit, and more so when the relative priority on achieving the full-employment target ( $\bar{\psi}$ ) is high. An increase in the desired change in output in Europe prompts an increase in the European deficit, which increases US output and therefore the US can afford to have a tighter deficit ( $\partial f_N^*/\partial \bar{y} < 0$ ). An increase in the desired change in US output only leads to a tighter European deficit when a US fiscal expansion is a locomotive policy, but otherwise it leads to a looser European deficit ( $\partial f_N/\partial \bar{y}^* \gtrless 0$  when  $\omega_2 \gtrless 0$ ). The optimal public deficits of the Nash equilibrium solution are time-inconsistent, because when the governments re-optimize it pays them to reset the public deficits to (6.10) and (6.11) with  $\rho$  set equal to zero. In fact, the "loss-of-leadership" solution (Buiter, 1984) corresponds to (6.10) and (6.11) with  $\rho$  set equal to zero. It corresponds to higher public deficits when both countries' policies are locomotive policies ( $\omega_2 > 0$ ), but otherwise the US public deficit may be smaller.

The outcome under international policy coordination minimises a global welfare loss function, where  $\omega$  is the relative weight of the European welfare loss. The steady-state reactions for the cooperative outcome are :

$$f = -\psi(y - \bar{y}) - \omega^{-1}\psi_*(y^* - \bar{y}^*) \quad (6.12)$$

$$f^* = -\psi^*(y^* - \bar{y}^*) + \omega\psi_*(y - \bar{y}) \quad (6.13)$$

where  $\psi_* \equiv \bar{\psi}[\omega_2^* + \rho\omega_1^*\omega_0(\omega_5 - \rho)^{-1}] > 0$  and  $\psi_*^* \equiv \bar{\psi}[\omega_2 + \rho\omega_1\omega_0(\omega_5 - \rho)^{-1}]$  is positive (negative) when a US fiscal expansion is a beggar-thy-neighbour (locomotive) policy. Hence, as long as fiscal expansions are locomotive policies, they respond to unemployment at home and abroad. However, if a US fiscal expansion is a beggar-thy-neighbour policy, the US tightens its deficit when there is unemployment in Europe. The resulting asymptotic levels of the public deficit under cooperation are :

$$f = \frac{\{\Delta_N f_N + \psi_*\psi_*^*(\omega_1^*\bar{y} + \omega_2\bar{y}^*) + \omega^{-1}\psi_*\bar{y}^*\}}{\{\Delta_N + \omega_2\psi_*^*(\omega + \psi_*\omega_2^*) + \omega_2^*\psi_*\omega^{-1} + \psi_*^*\omega_1^*\psi_*\omega_1\}} \equiv f_c \quad (6.14)$$

$$f^* = \frac{\{\Delta_N f_N^* + \psi_*\psi_*^*(\omega_1\bar{y}^* - \omega_2^*\bar{y}) - \omega\psi_*^*\bar{y}\}}{\{\Delta_N + \omega_2\psi_*^*(\omega + \psi_*\omega_2^*) + \omega_2^*\psi_*\omega^{-1} + \psi_*^*\omega_1^*\psi_*\omega_1\}} \equiv f_c^* \quad (6.15)$$

Intuitively, one expects that the European fiscal stance is too tight ( $f_N < f_c$ )

and that, when a US fiscal expansion is a beggar-thy-neighbour policy, the US fiscal stance is too loose ( $f_N^* > f_C^*$ ). However, this result does not follow immediately. To illustrate the conditions under which this result holds, it is best to consider two special cases.

Consider the case where the world planning authority only cares about US welfare ( $\omega \rightarrow 0, \bar{y} = 0$ ). In that case, it is easy to show that the planner allows the US to maintain a public sector deficit consistent with no inflation ( $f_C^* = 0$ ) whilst Europe is forced to have an inflationary deficit in order to achieve full employment in the US ( $f_C = \bar{y}^* / \omega_2^* > 0$ ). In the absence of international policy coordination, the US fiscal stance is too loose ( $f_N^* > f_C^* = 0$ ) whilst the European fiscal stance is too tight ( $f_N = f_C (\omega_2 \omega_2^* \psi \psi^* / \Delta_N) < f_C$ ). This explains why the US urges Europe to expand, especially as this would justify a fiscal contraction in the US (see (6.9)). To understand Europe's reluctance to engage in a fiscal expansion, consider the case where the world planning authority only cares about European welfare ( $\omega \rightarrow \infty, \bar{y}^* = 0$ ). Now the world planner allows Europe to have a zero-inflation deficit ( $f_C = 0$ ) whilst the US must, typically, have a deflationary deficit in order to achieve full employment in Europe ( $f_C^* = -\bar{y} / \omega_2 < 0$  for  $\omega_2 > 0$ ). Now absence of international policy coordination means that the European fiscal stance is too loose ( $f_N > f_C = 0$ ) and the US fiscal stance is, typically, also too loose ( $0 > f_N^* = f_C^* (\omega_2 \omega_2^* \psi \psi^* / \Delta_N) > f_C^*$  for  $\omega_2 > 0$ ). Since the European fiscal stance is now too loose, it is understandable that the European governments have been reluctant to succumb to US pressure to expand.

It is possible to generalise the above results to allow both countries to have an unemployment problem ( $\bar{y}, \bar{y}^* > 0$ ). When the world planner only cares about US welfare ( $\omega \rightarrow 0$ ), it can be shown that  $f_N < f_C = \bar{y}^* / \omega_2^*$  and (as long as  $f_N^* > 0$ )  $f_N^* > f_C^* = 0$  still holds. Also, when only European welfare matters ( $\omega \rightarrow \infty$ ), it can be shown that  $f_N > f_C = 0$  and  $f_N^* > f_C^* = -\bar{y} / \omega_2$  still hold for the case  $\omega_2 > 0$ .

It is clear that, whatever the weights the world planner attaches to US and European welfare (or whatever the relative bargaining strengths of the US and Europe), the US fiscal stance is too loose and therefore policy coordination involves a reduction in the US deficit. It is not so clear what policy coordination implies for the European fiscal stance. If the US has its way, international policy coordination implies that Europe would expand. However, if Europe has more bargaining strength, coordination implies that it would reduce its public sector deficit.

So far it has been assumed that a US fiscal expansion is a beggar-thy-neighbour policy ( $\omega_2 > 0$ ). If it is a locomotive policy ( $\omega_2 < 0$ ), a dominant US ( $\omega \rightarrow 0, \bar{y} = 0$ ) implies, as before, that the US fiscal stance is too loose

( $f_N^* > f_C^* = 0$ ) and the European fiscal is too tight ( $f_N < 0 < f_C$ ) whilst a dominant Europe ( $\omega \rightarrow \infty$ ,  $\bar{y}^* = 0$ ) implies that the European fiscal stance is too loose ( $f_N > f_C = 0$ ) and the US fiscal stance is too tight ( $f_N^* < 0 < f_C^*$ ).

So far, the analysis considered bond-financed changes in the public sector deficit. Now consider money-financed changes. For Europe this will not make much difference, because it is assumed that its economy is fully indexed. For the US the government budget constraint, under money-finance and nominal wage rigidity, can be written as

$$\dot{m}^* = \exp[f^* - (m^* - p^*)] = \exp(f^* + \tau^* + \bar{\beta}_2 p_n^*), \quad (6.16)$$

where  $f^*$  includes interest payments on the government debt. Even if bond-financed increases in the US deficit are a beggar-thy-neighbour policy ( $\omega_2 > 0$ ), it may be, particularly at high rates of monetary growth, that money-financed increases in the US deficit are a locomotive policy (if  $\omega_3 \dot{m}^* > \omega_2$ ). Hence, the optimal US public sector deficits are, in the absence of international policy coordination, more likely to be too tight when they are money-financed than when they are bond-financed.

## VII. CONCLUDING REMARKS

Empirical evidence shows that in the eighties US monetary policy has been relatively tight, US fiscal policy has been relatively loose, and European fiscal policy has been relatively tight. This period has also seen a huge rise in European unemployment. Econometric analysis shows that one cannot reject the hypothesis of real wage rigidity for Germany, France, Italy and Japan at the 5 per cent significance level, but that Canada, the UK and the US do display a significant degree of nominal wage rigidity in the short run. Incorporation of these stylistic facts in a two-country model with sluggish output and labour markets, efficient and integrated financial goods shows that a US monetary expansion and a European fiscal expansion are locomotive policies. A US fiscal expansion is, typically, a beggar-thy-neighbour policy, because the negative effects of financial crowding out on European consumption and investment are assumed to dominate the positive spill-over effects of US activity on European exports. Also, an increase in the real price of oil, such as the OPEC oil shocks, leads to a rise in the world real interest rate and, typically, to a depreciation of the European real exchange rate. This means that the adverse effects on aggregate supply are attenuated in the US and accentuated in Europe, so that an oil shock typically hits Europe much harder than the US. It is not surprising that, in the absence of international policy

coordination and in the aftermath of the OPEC oil shocks, the European fiscal stance and US monetary growth have been too tight whilst the US fiscal stance has been too loose. It is also clear that each of these three policies have contributed to the recent rise in European unemployment.

The comparative statics results derived in this paper are summarised in Table 2.

TABLE 2

Summary of the Effects of Home Shocks on Home Output ( $y$ ), Foreign Output ( $y^*$ ), the Home Real Exchange Rate ( $c$ ), and the Real Interest Rate ( $r$ )

	Section 4 NWR-NWR*	Section 5 RWR-RWR*	Section 6 RWR-RWR*	Section 6 NWR-NWR*
Fiscal expansion	+, +, -, +	+, -, -, +	+, +, -, +	+, ?, ?, +
Expansion in monetary growth	+, -, +, -	0, 0, 0, 0	0, 0, 0, 0	+, +, +, -
Cut in employers' tax rate	+, -, +, -	+, +, +, -	+, -, +, -	+, +, +, -

*Note*: The effects of a home fiscal expansion in a *NWR-RWR\** world are an appreciation (depreciation) of the home real exchange rate and a fall (increase) in foreign output when the negative effect of financial crowding out on foreign consumption and investment dominate (are dominated by) the positive spill-over effects of home activity on foreign exports, that is when  $\bar{\sigma}\gamma/\lambda$  exceeds (is less than)  $\gamma$ .

*London School of Economics, U.K.*

## DATA APPENDIX

Standardised unemployment rates. Source: *OECD Employment Outlook*, 1986.

Deflator of consumers' expenditure,  $P_c$ . Source: *OECD National Accounts*, various issues.

Inflation in the deflator of consumers' expenditure,  $\Delta p_c$  where  $p_c \equiv \log(P_c)$ .

Long nominal interest rate,  $r_L$ , generally the yield on long-term government bonds. Source: *IMF International Financial Statistics Yearbook*, 1983 and January 1984.

Short nominal interest rate,  $r_s$ , generally Central Bank's discount rate or a treasury bill rate. Source: *IMF International Financial Statistics Yearbook*, 1983 and January 1984.

Realised short real interest rate,  $r_s - \Delta p_c$ .

Real competitiveness,  $\log(P_m/P)$ .



- Deflator of imports,  $P_m \equiv MC/MQ$  where  $MC$  denotes imports at current prices and  $MQ$  denotes imports at 1980 prices. Source: *OECD National Accounts*, various issues.
- Deflator of value added,  $P \equiv YC/YQ$  where  $YC$  denotes  $GDP$  at current prices and  $YQ$  denotes  $GDP$  at 1980 prices. Source: *OECD National Accounts*, various issues.
- Actual, structural and inflation-adjusted structural budget balances. Source: *Muller and Price*, 1984, Tables A1.1 - A1.7 and A3.5.
- Employers' tax rate,  $t_1 \equiv EC/(IE-EC)$  where  $EC$  denotes employers' contributions to social security and private pension schemes and  $IE$  denotes income from employment. Source: *OECD National Accounts*, various issues.
- Employees' tax rate,  $t_2 \equiv DT/HCR$  where  $DT$  denotes direct taxes and employees' contributions to social security and  $HCR$  denotes households current receipts. Source: *OECD National Accounts*, various issues.
- Indirect tax rate,  $t_3 \equiv (TX - SB)/YC$  where  $TX$  denotes indirect taxes and  $SB$  denotes subsidies. Source: *OECD National Accounts*, various issues.
- Import price component of the wedge,  $t_m$ , defined as the share of imports in final expenditures,  $MC/(MC + YC)$ , times  $\log(P_m/P)$ .
- Wedge,  $t_1 + t_2 + t_3 + t_m$ .
- Nominal wage,  $W$ , which is hourly earnings in manufacturing. Source: *OECD MEI Historical Statistics*, 1955-71 and 1960-79.
- Wage inflation,  $\Delta w$  where  $w \equiv \log(W)$ .
- Real producers' wage,  $W(1 + t_1)/P$ .
- Real consumers' wage,  $W(1 - t_2)/P_c$ .
- Unemployment rate,  $u \equiv UT/ET$  where  $UT$  denotes total unemployment and  $ET$  denotes total employment (including armed forces) Source: *OECD Labour Force Statistics*, various issues.
- Trend productivity of labour,  $PROD \equiv \frac{1}{3} \log(YF/ET) + \frac{1}{3} \log(YF/ET)_{-1} + \frac{1}{3} \log(YF/ET)_{-2}$  where  $YF \equiv (YC - TX + SB)YQ/YC$  denotes  $GDP$  at factor cost and 1980 prices.
- Measure of industrial conflicts,  $NC$  (see M. Paldam and Rasmussen, 1981, "Data for Industrial Conflicts in 17 OECD countries, 1948-77", Aarhus University) Source: *ILO Yearbook of Labour Statistics*, various issues.

All the data, except the structural budget balances, can be found in the *OECD* databank of the Centre for Labour Economics (see A. Newell, 1985, "The Revised *OECD* Data Set", London School of Economics, Working Paper No. 781, which includes D. Grubb, "The *OECD* Data Set").

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