NBER WORKING PAPER SERIES

INTERNATIONAL ADJUSTMENT WITH WAGE RIGIDITY

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Working Paper No. 406

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

November 1979

The research reported here is part of the NBER's research program in International Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper 406
November 1979

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ABSTRACT

Two of the puzzling macroeconomic phenomena of the 1970s have been the persistent stagnation in Europe, and the disagreement between the U.S. and Europe on the feasibility of recovery by demand expansion. This paper developes the hypothesis that the source of both the stagnation and the policy differences is money-wage stickiness in the U.S. and real-wage stickiness in Europe and Japan. A real wage which is sticky above its equilibrium level in Europe and Japan would account for stagnation and infeasibility of recovery by demand expansion. The theoretical models are developed in both the one-commodity and two-commodity-bundle cases. The empirical results confirm that in the U.S. the nominal wage adjusts slowly toward equilibrium, while in Germany, Italy, Japan, and the U.K. the real wage adjusts slowly.

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I. Background and Introduction

Since 1974 the OECD area has seen several attempts at recovery from the 1974-75 recession, but the result has been stagnation. The recovery of 1975-77 in the United States took it well ahead of the rest of the OECD in the business cycle, even though the unemployment rate reached a low of only 5.7 percent. The U.S. recovery led to a massive increase in its current account deficit and the sharp depreciation of the dollar in 1978. The "balance of payments constraint" on uncoordinated recovery reappeared as an "exchange-rate constraint."

In November 1978 U.S. policy shifted sharply toward restraint and support for the dollar; the shift was announced publicly by President Carter. Demand policy has remained tight ever since, especially with monetary policy tightening in West Germany in 1979. The tightening of U.S. policy simply recognizes that the U.S. cannot attempt recovery significantly faster than Europe or Japan. The OECD countries appear to be locked into a system in which economic growth is significantly limited by the growth rate of the slowest major participant. The result of the shift in policy is renewed recession and rising unemployment throughout the OECD area.

The constraining factor in the stagnation since 1974 seems to be the difficulty of recovery, or reluctance to stimulate demand, in Europe and Japan. The question we address is: why is recovery so hard in Europe and Japan? During 1976-77 the OECD policy debate on recovery was mainly the U.S. suggesting (more or less politely) that the countries in "strong" current account positions, Japan and West Germany, take the lead, and those governments either refusing or reluctantly proposing fairly timid measures.

Essentially their position was that rapid demand expansion would lead only to more inflation, with no significant gains in real output.

One popular explanation for the policy difference between the U.S. and, mainly, West Germany was that their sensitivity to or expectations of inflation differed. Another could be that the implicit model behind the German view was a textbook "classical" model with no money illusion and fully flexible wages and prices, while the implicit U.S. model has sticky wages or money illusion. This view of the German economy did not seem realistic.

A more satisfactory model of the European side was presented by Herbert Giersch when he talked in Princeton on March 1, 1978. Our interpretation of his view was that the German real wage was rigid, at least downward, above its equilibrium value. This model would give the "classical" results that demand expansion only raises prices with no effect on output, but not in a flexible wage-and-price context. As we see in Section II below, an assumption of real-wage rigidity of this sort in Europe and Japan plus nominal wage stickiness in the U.S. would make sense of the 1976-77 policy debate.

As an initial check on the empirical plausibility of this model, we perused the time-series data on real wage rates in major OECD countries. If differences between real-wage and nominal-wage rigidities were a major feature of the OECD economies, they should appear in the 1974 recession, with rigid real wages resisting the downturn more than sticky nominal wages. This is especially true with the oil price increase.

The time-series data are summarized in Table 1. There we see that the only country with a protracted decline on real wages in the 1973-75 period was the United States. There the real wage index peaked at 1.042 in 1973:2, and did not pass that level again until 1975:2. In Germany, real wage growth continued straight through the recession until 1976. In Italy and Japan there was a pause in 1974, with growth resuming by the beginning of 1975. In the U.K. the real wage index continued to grow to mid-1976, with pauses in 1974:2 and in mid-1975. These data provide some initial support for the

Table 1

INDEX OF REAL HOURLY COMPENSATION OF EMPLOYEES FOR SELECTED OECD COUNTRIES

YEAR	GERMANY	ITALY	JAPAN	U.K.	U.S.
1971:1	1.000	1.000	1.000	1.000	1.000
1971:2	0.997	1.036	1.024	1.025	1.001
1971:3	1.029	1.058	1.053	1.012	1.003
1971:4	1.031	1.049	1.065	1.025	1.003
1972:1	1.057	1.057	1.116	1.037	1.016
1972:2	1.067	1.095	1.116	1.076	1.023
1972:3	1.076	1.111	1.124	1.069	1.027
1972:4	1.086	1.176	1.197	1.072	1.030
1973:1	1.119	1.177	1.142	1.064	1.042
1973:2	1.125	1.236	1.173	1.080	1.036
1973:3	1.139	1.259	1.222	1.088	1.034
1973:4	1.147	1.270	1.307	1.088	1.029
1974:1	1.161	1.255	1.169	1.121	1.018
1974:2	1.196	1.317	1.280	1.120	1.024
1974:3	1.228	1.277	1.305	1.164	1.024
1974:4	1.245	1.293	1.305	1.190	1.032
1975:1	1.262	1.356	1.340	1.204	1.041
1975:2	1.265	1.369	1.311	1.186	1.049
1975:3	1.276	1.414	1.307	1.191	1.047
1975:4	1.282	1.390	1.312	1.203	1.051
1976:1	1.277	1.391	1.312	1.208	1.057
1976:2	1.279	1.407	1.300	1.221	1.072
1976:3	1.294	1.434	1.300	1.217	1.075
1976:4	1.300	1.401	1.313	1.192	1.082
1977:1	1.298	1.391	1.309	1.168	1.085
1977:2	1.318	1.418	1.314	1.150	1.086
1977:3	1.319	1.415	1.324	1.155	1.095
1977:4	1.348	1.423	1.339	1.174	1.103
1978:1	1.331	1.441	1.343	1.195	1.112
1978:2	1.364	1.421	1.345	1.227	1.106
1978:3	1.362	1.421	1.349	1.232	1.109
1978:4	1.385	1.432	1.362	1.248	1.109

hypothesis, and were the basis for an informal discussion of it at the International Seminar on Macroeconomics in 1978. This paper reports on our continuing theoretical and empirical investigation of demand policy in a series of models with differing types of wage rigidity across countries.

In Section II of the paper we develop a model of two countries with one commodity and purchasing-power-parity (PPP). Here we obtain the clear-cut Giersch results. Expansion in the country with rigid real wages raises the world price level, increases output in the country with rigid nominal wages, and also reduces that country's trade deficit.

The clarity of these results is blurred in Section III, where we study a model with two commodities and do not assume PPP. This is the same general framework used by Bruno and Sachs [1979] and Argy and Salop [1978]. The main differences are that the Section III model is analytic and focuses on effects of demand policy, while Bruno-Sachs' several-country model is solved by simulation and focuses on analysis of stagflation. Argy-Salop look only at supply-side conditions, while we study demand and supply. As we see in Table 3, the Bruno-Sachs and Argy-Salop results can be viewed as special cases of ours.

The reason that the clear-cut Giersch results are lost in the two-commodity case is that the relevant prices for workers' and producers' decisions are different [as in Bruno-Sachs and Argy-Salop]. Producers look at the price of domestic output; workers look at a CPI with imports in it as well. Thus even if the real wage relative to the CPI is rigid, if a demand expansion at home pulls up the price of domestic output relative to the CPI, employment and output expands. Only if exchange-rate adjustment were immediate and complete, putting us back in the Section II PPP world, would the difference not appear. The result is that, in Section III, we see that the degree of "money illusion," or real wage vs. nominal wage stickiness, is at least as important as actual wage rigidity for sorting out the effects of demand policy.

In Section IV we report some empirical tests of wage rigidity and money illusion for five major OECD countries (U.S., U.K., Japan, Italy, Germany) on time-series data since 1961. The sample is split at 1971 to see if parameters have changed in the 1970s. An important thing to note about our Table 4 regressions is that they report equations for gradual adjustment of wage levels, with lagged wages and the level of demand as regressors. This formulation follows from the theory of Sections II and III, where wage rigidities are stated in terms of the relevant wage level. Bruno-Sachs [1979, p. 16] have the same basic theoretical structure but estimate Phillips-type equations with the wage change depending on the level of demand.

The empirical results give us a classification as follows. The U.S. stands out as the only country with short-run stickiness of nominal wage rates. The U.K., Japan, Germany, and Italy all seem to have gradual adjustment of real wages, consistent with effective indexation. In all five countries, response of the relevant wage to demand pressure is much less in the 1970s than over the entire period. These results are consistent with the Giersch hypothesis extended to the OECD.

II. Wage Rigidities in the PPP Model

In this section we develop the simplest macro model with wage rigities that yields interesting results for the effects of demand policy. The model has two countries and one commodity (the "schmoo"), and assumes that the "law of one price" holds, so that there is one world price, P, for the one commodity.[1/] We hold the exchange rate constant at unity; alternatively we could assume two different domestic prices for the commodity, P and P*, with the exchange rate e defined by $P = eP^*$. We begin with the specification of aggregate supply conditions, then move on to demand in each country and determination of the equilibrium price level. Next we study the effects of demand policy and the consequences of different forms of wage rigidity.

Labor Market and Aggregate Supply

On the demand side of the labor market we have a production function and a marginal productivity condition which yields the labor demand function

(1) $y = y(N; K);$ $\quad y_N > 0;\ y_{NN} < 0;$ (production function)

$y_K > 0;\ y_{NK} < 0.$

(2) $w = W/P = y_N(N; K).$ (demand wage)

In an equilibrium model, we would add a labor-supply function $w = w^S(N)$, and solve for equilibrium w and N. Here we assume that alternately either the nominal wage or the real wage is rigid above its equilibrium value. We assume that with the relevant wage rigid above its equilibrium level, employment is determined along the labor demand function. This is the familiar minimum condition in non-market-clearing models.[2/] Thus if the wage rigidity is

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1/ See Table 2 for definition of variables.

2/ See Muellbauer and Portes [1979], for example.

Table 2: Definition of Variables

y	domestic output
P	price index for y
W	nominal wage rate
w	real wage rate
K	capital stock
g	exogenous component of demand in real terms
a	real absorption
x	real net exports
*	superscript for the "foreign" country

effective, labor is constrained in the amount of hours that employers will buy. This is consistent with the specification of the demand side in the next sub-section.

In the case of the real wage rigidity we have $w = \bar{w} >$ equilibrium w, and employment is determined along the labor demand function:

$$(3) \qquad w = y_N(N; K).$$

This gives us N as a function of $\bar{w}$ and the production technology, and through (1) it fixes y from the supply side. This is similar to the textbook "classical" model (see Branson [1979]) and is illustrated in Figure 1.

With a nominal wage rigidity we have

$$(4) \qquad \bar{W} = P \cdot y_N(N, K)$$

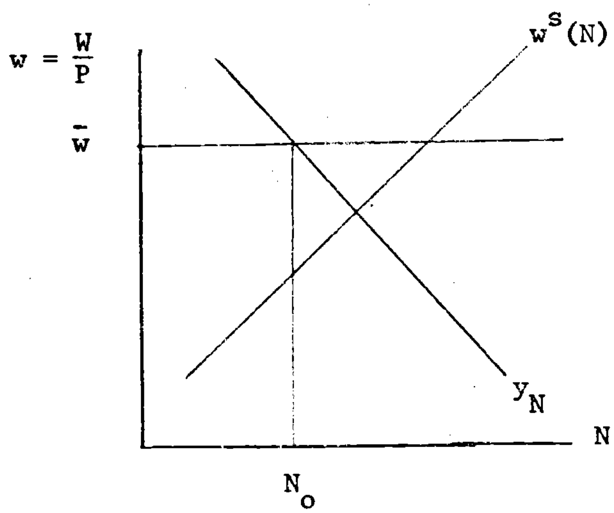
as the labor-market equilibrium (but non-clearing) condition. This is illustrated in Figure 2. The response of employment and aggregate supply to a change in the price level is obtained from total differentiation of (4) and the production function (1):

$$(5) \qquad \left.\frac{dN}{dP}\right|_{\substack{w=\bar{w}\\ dK=0}} = -\frac{y_N}{y_{NN}} > 0; \qquad \left.\frac{dy}{dP}\right|_{\substack{w=\bar{w}\\ dK=0}} = y_N \frac{dN}{dP} > 0.$$

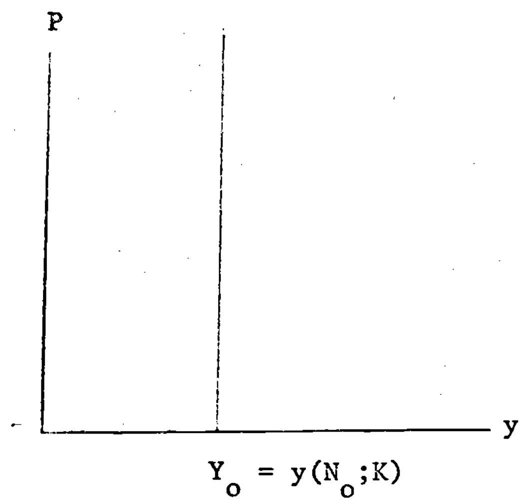
The response of aggregate supply to an increase in the capital stock is given by

$$(6) \qquad \left.\frac{dy}{dK}\right|_{\substack{w=\bar{w}\\ dP=0}} = -y_N \frac{y_{NK}}{y_{NN}} > 0.$$

Figure 1: Real wage rigidity

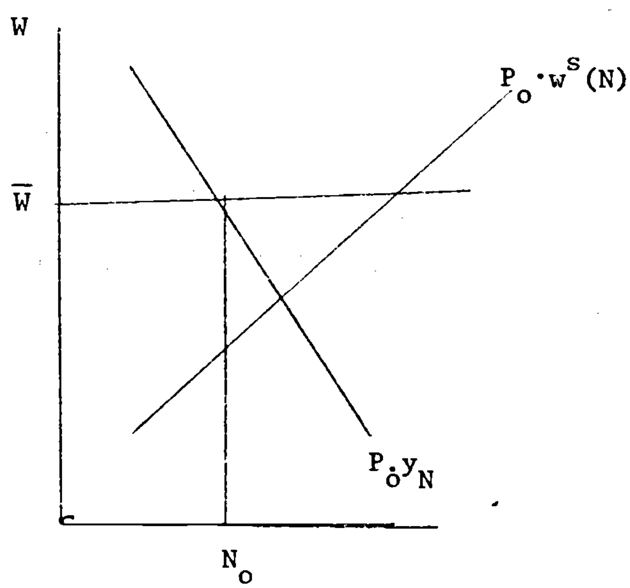


(a) labor market

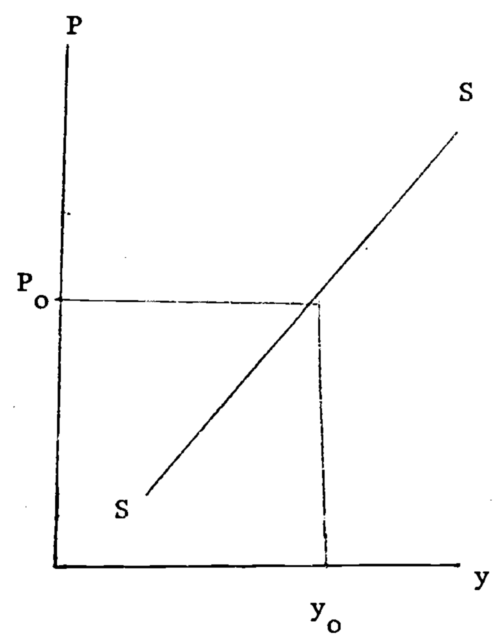


(b) Aggregate supply

Figure 2: Nominal wage rigidity



(a) labor market



(b) Aggregate supply

An increase in the capital stock shifts out the supply curve in Figures 1 and 2. Thus with the rigid nominal wage we can write the aggregate supply function of Figure 2(b) as

$$(7) \qquad y = y(P; K); \quad y_P \geq 0; \; y_K \geq 0$$

with a rigid real wage $y_P = 0$; with a rigid nominal wage $y_P > 0$.

In the two-country model we will assume that each country has an aggregate supply function of the form $y = y(P, K)$. The "home" country will be identified by unstarred variables; the "foreign" country by stars. Thus the two aggregate supply functions are

$$(8a) \qquad y = y(P, K);$$

$$(8b) \qquad y^* = y^*(P, K^*).$$

Remember that there is only one world price level.

In the solution for equilibrium and comparative statics below we will assume $y_P > 0$; $y^*_P > 0$ in general. Then when we analyze the effects of differing wage rigidities on the results of demand policy we will assume the "home" country has a real wage rigidity so that $y_P = 0$, and the "foreign" country has a nominal wage rigidity with $y^*_P > 0$. The effects of changes in investment will come in only when we discuss policy to adjust to a real wage rigidity, so we omit the K argument in y and y^* until we reach that discussion.

Demand and Equilibrium P

With rigid wages above equilibrium in both countries, real absorption will be a function of income, the price level, and a demand policy variable. Income appears through a Keynesian effective-demand consumption function. The price level represents a real balance effect with predetermined outside money. The demand policy variable can be thought of as the real deficit, or real government purchases with given tax revenue. The income-expenditure equilibrium conditions for the two countries are then

$$(9a) \qquad y(P) = a(y(P), P, g) + x;$$

$$(9b) \qquad y^*(P) = a^*(y^*(P), P, g^*) - x.$$

Here net exports (the current account balance of the home country) x is residually determined by income y less absorption a. With only one good there are no terms-of-trade effects. This simplification will be removed in Section III below. With two countries, x enters negatively in (9b). The partial derivatives of a are signed $a_y > 0$, $a_p < 0$, $a_g > 0$ (=1), and similarly for a^*.

The equilibrium world price level P is obtained by equating income less absorption at home to absorption less income abroad:

$$(10) \qquad y - a = -(y^* - a^*).$$

Here we sum the excess demand functions in the two countries and find the price level at which world excess demand is zero.

The next step is to derive expressions for the effects of changes in demand policy g and g^* on the price level. The effects on outputs y and y^* will follow immediately from the supply functions. The effects on the current account x can then be solved from (9a) or (9b). Total differentiation of (10) and solution for dP yields

$$(11) \qquad dP = \frac{1}{\phi + \phi^*} (dg + dg^*),$$

where $\phi = (y_p(1-a_y) - a_p) > 0$, and $\phi^* = (y_p^*(1-a_y^*) - a_p^*) > 0$. Remember $a_g = 1$. The effect of demand expansion on the price level does not depend on where it originates. The parameters ϕ and ϕ^* are Keynesian-type multipliers.

The effect of demand expansion on net exports can be solved from the total differential of (9a):

$$(12) \qquad dx = - \frac{\phi^*}{\phi + \phi^*} dg + \frac{\phi}{\phi + \phi^*} dg^*.$$

An exogenous increase in home demand reduces x; an increase in foreign demand increases x. If both g and g^* rise by the same amount, the effect on x depends on the net absorption coefficients ϕ and ϕ^*. If $\phi > \phi^*$, a balanced expansion increases x since net absorption falls more at home than abroad.

The increase in outputs y and y^* that follows from an increase in g or g^* are simply $dy = y_p dP$ and $dy^* = y_p^* dP$. Thus if the supply curves have positive slopes, both levels of output and employment are increased by a demand expansion in either country.

The Role of Wage Rigidities

We can now use the one-commodity model to study the effects of differing wage rigidities on response to changes in demand policy. To be specific, let us assume that in the home country the real wage is rigid above equilibrium, while in the foreign country the nominal wage is rigid. Thus $w = \bar{w}$; $W^* = \bar{W}^*$, by assumption. What are the consequences for the effects of a demand expansion?

First, with a real wage rigidity at home $y_p = 0$ and ϕ in equation (11) reduces to $-a_p$. When the price level rises, there is an effect on absorption in the real-wage country, but no effect on output. The reaction of the world price level with this pattern of wage rigidities is given by

$$(13) \qquad dP = \frac{1}{\phi^* - a_p} (dg + dg^*).$$

The source of the demand disturbances still does not matter, but the price multiplier is increased from equation (11) by elimination of the y_p^* output effect. The expression for dx in equation (12) is also changed by substitution of $-a_p$ for ϕ. It is still the case that $dx/dg < 0$ and $dx/dg^* > 0$, but it is more likely that a balanced increase in g and g^* decreases x because of the zero supply response in the home country.

To summarize, an increase in g in the real-wage country (a) increases P, and by more than in a world with no real-wage rigidity, (b) increases output <u>only</u> in the other country, and (c) reduces the trade surplus in the real-wage country. Thus <u>if</u> Germany were the real-wage country and the U.S. were the nominal wage country, a fiscal expansion in Germany would be inflationary and reduce the German trade balance, but all the output and employment effects would appear in the U.S.

This model can be generalized easily to a world of several countries, some with real wage rigidities, some with nominal wage rigidities. A demand expansion originating anywhere in the system will raise the price for all, but increase output and employment only where nominal prices are rigid. The trade surplus (deficit) will be reduced (increased) in the area where the demand expansion originated, and a balanced expansion of demand will reduce the trade surplus of the real-wage countries.

<u>Effect of Capital Stock Expansion</u>

Expansion of the capital stock in one country will increase supply in that country, drive down the world price level, and in general reduce output in the other country. We can see this by putting (8a) and (8b) for y and y^* into the equilibrium conditions (9a) and (9b), inserting these into (10) for the world price level, and totally differentiating with respect to P and K. The result is

$$\frac{dP}{dK} = - \frac{y_K(1-a_y)}{\phi + \phi^*} < 0.$$

If the home (unstarred) country increases its capital stock, its output rises unambiguously. The expression for dy is

$$dy = y_K(1 - \frac{y_P(1-a_y)}{\phi + \phi^*})dK.$$

Since $y_P(1-a_y) < \phi$, $dy/dK > 0$.

If the real wage in the home country is rigid above equilibrium, so that $y_P = 0$, capital stock expansion can increase output to the point where the wage rigidity is no longer binding on the side of the demand for labor. Thus one policy to escape the wage rigidity is incentives for investment. This was Giersch's conclusion for West Germany. However, by reducing the world price level P, this policy would tend to reduce output abroad unless $y_P^* = 0$.

III. Adjustment with Differentiated Product Bundles

The clear-cut results of Section II were derived in a framework with only one good and one world price level. The sharpness of these results is reduced when we go to a world of differentiated product bundles with different prices. In reality the industrial countries trade products that can be roughly aggregated into bundles of exportables and importables, with the possibility of terms-of-trade changes between them. To capture the effects of movements in the terms of trade, we turn to a model in which the two countries produce different goods. These can be thought of as different fixed-weight product bundles with their associated price indexes. Introduction of two goods, and two prices, changes fundamentally the characterization of both the supply and demand sides of the model, and makes the signs of the effects of expansionary policy in either country on both outputs depend on particular parameter values.

The Demand Side with Two Commodities

In this section we develop a fairly standard two-country Keynesian model with two goods. The two goods are the home exportable y with a price index P, and the foreign exportable y^* with a price index P^*. In this framework we again study the effects of differing wage rigidities, i.e., aggregate supply specifications, on the effectiveness of demand policy in influencing output.

On the demand side we have the usual absorption equation for an open economy:

$$y = a(y, \hat{P}, g) + x(P/eP^*). \tag{14}$$

The consumer price index entering absorption is a function of the home and foreign prices:

$$(15)\qquad \hat{P} = \theta(P,\ P^{*});\qquad \theta_p,\ \theta_p*,\ \geq 0;\qquad \theta_p + \theta_p* = 1.$$

The restriction on the sum of θ_p and θ_p* follows from specification of $\hat{P}$ as a weighted average of P and P^*, and the initial normalization $P = P^* = 1$.

Total differentiation of (14), holding the exchange rate constant at $e = 1$, yields:

$$(16)\qquad dy = \frac{1}{1 + a_y}\,[(a_p\ \theta_p + x_p)dP + (a_p\ \theta_p* - x_p)dP^* + dg].$$

Here $x_p < 0$ is the derivative of x with respect to eP/P^*. From (16) we can write the demand function for y:

$$(17)\qquad y = V(P,\ P^*,\ g);\qquad V_p < 0;\qquad V_p* > 0;\qquad V_g > 0.$$

The partial derivatives of V are the coefficients in equation (16) above. $V_p* > 0$ assumes that the terms of trade effect outweighs the absorption effect when the foreign price level P^* rises. If the home good share in the consumption bundle is at least equal to the import share, $\theta_p \leq \theta_p*$, then $|V_p| > |V_p*|$. This condition is not necessary since x_p enters V_p while $-x_p$ enters V_p*.

Aggregate Supply with Two Commodities

On the supply side we first develop expressions for labor market supply, demand, and equilibrium, and then show how these are affected by the existence of wage rigidities above equilibrium levels.

The production function is equation (1) of Section II, where output is the exportable good. The usual demand function for labor is given in equation (2) above: $\frac{W}{P} = y_N(N)$. As an alternative we also introduce the possibility that producers have market power in both home and foreign markets, and can effectively prevent entry in the short run. In this case, both the home and foreign prices would enter the demand function for labor:

(18) $$\frac{W}{\tilde{P}} = y_N (N),$$

with $\tilde{P}$ defined by:

(19) $$\tilde{P} = \psi(P, P^*); \qquad \psi_p, \psi_p* \geq 0; \qquad \psi_p + \psi_p* = 1.$$

In the competitive case $\tilde{P} = P$, and $\psi_p = 1$. However, (19) provides the price index for a discriminating monopolist producing at home and selling in both markets.1/ In the algebra that follows, the competitive case can be obtained by setting $\psi_p = 1$ and $\psi_p* = 0$.

The labor supply function makes the real wage demanded a function of the level of employment, with the nominal wage deflated by the consumer price index $\hat{P}$ defined earlier in equation (15). Thus labor supply is given by:

(20) $$\frac{W}{\hat{P}} = g(N); \qquad g_N > 0.$$

Equilibrium in the labor market equates the nominal supply wage from (20) to the demand wage from (18):

(21) $$\hat{P} \cdot g(N) = \tilde{P} \cdot y_N(N).$$

Total differentiation of (21) plus the production function (1) gives us the expression for changes in y as functions of dP and dP^* on the supply side:

(22) $$dy = \frac{1}{g_N - y_{NN}} [(\psi_p - \theta_p)dP + (\psi_p* - \theta_p*)dP^*].$$

1/For detailed analysis and proof, see Appendix A.

Here we have set all prices at unity initially. It may help to note that this implies also that initial $w = g = y_N = 1$.

From (22) we can write the general form of the supply function for y as:

(23) $y = \Lambda(P, P^*)$; $\Lambda_p \geq 0$; $\Lambda_p^* \leq 0$.

The signs of the partial derivatives of (23) are the coefficients of (22), where we assume $\theta_p^* > \psi_p^*$. This simply says the weight of foreign prices in the worker's CPI is larger than it is in the firms' profits function.

An interesting property of the Λ supply function should be noted here. If workers focus on the real wage, correctly measured, in making the labor supply decision, then $\theta_p + \theta_p^* = 1$. Together with $\psi_p + \psi_p^* = 1$, this implies that $\Lambda_p = -\Lambda_p^*$; the supply function is symmetric with respect to the two prices.

The Role of Wage Rigidities

We can now introduce wage rigidities on the supply side as special cases of (22) and (23). Consider first the case in which the real wage is rigid above equilibrium. We interpret this as an infinitely elastic supply curve for labor at the rigid wage $\bar{w}$, so that the supply function (20) becomes:

(20R) $\frac{W}{\hat{P}} = \bar{w}$,

and in (22) $g_N = 0$.

This simply removes g_N from (22) and (23), not changing the qualitative slopes of (23). Thus going to a two-good model fundamentally changes the "classical" effect of the real-wage rigidity. With the two price indexes entering differently in producers' demand for labor and in workers' supply, a change of either price influences output supplied, with $\partial y/\partial P > 0$ and $\partial y/\partial P^* < 0$ even with a real-wage rigidity. This will eliminate some of the sharp results of the one-commodity model.

To impose a nominal wage rigidity, we re-write (20) as:

(20N) $\quad W = \bar{W};$

in addition to $g_N = 0$, $\hat{P}$ no longer enters the supply function. This eliminates θ_p and θ_p* from (22) and (23). In the usual case of $\psi_p = 1$, this takes us back to the supply function of Section II, equation (5), with $\partial y/\partial P = -1/y_{NN}$.

With complete wage rigidity, or complete "money illusion" in labor supply, θ_p and $\theta_p* = 0$, since the price level does not enter the labor supply function as it affects the level of employment. With flexible nominal wages and no money illusion, $\theta_p + \theta_p* = 1$. In an intermediate case of partial money illusion, the labor force would "perceive" a price index with $\theta_p + \theta_p* < 1$. The perceived price index could be thought of as the actual CPI raised to a power less than unity: $\hat{P}^\alpha$ with $\alpha < 1$.[2/]

To summarize, real wage rigidity would eliminate g_N from (22) and nominal wage rigidity would further eliminate θ_p and θ_p*. Both types of rigidity would leave us with the supply function (23) with $\Lambda_p > 0$. The sign of Λ_p*, the cross-price effect on supply, is less clear. Normally $\Lambda_p* < 0$. However, in the case where $\psi_p = 1$, complete nominal wage rigidity would eliminate P^* from the Λ supply function. If ψ_p* is sufficiently large compared to θ_p*, then $\Lambda_p* > 0$.

<u>Demand and Supply in the "Foreign" Country</u>

Equations (17) and (23) give demand and supply in the home country as functions of the two price levels. At this level of generality, demand

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2/ See Branson and Klevorick [1969] for use of this parameterization of money illusion.

and supply in the foreign * country are mirror images. The only point to note especially is that the trade balance at home must equal the deficit abroad. Thus the demand equation in the * country is solved from:

(24) $y^* = a^*(y^*, \hat{P}^*, g^*) - x(eP/P^*)$.

The foreign demand equation is then:

(25) $y^* = V^*(P, P^*, g^*)$; $V^*_p > 0$; $V^*_{p^*} < 0$; $V^*_{g^*} > 0$;

The supply equation is:

(26) $y^* = \Lambda^*(P, P^*)$; $\Lambda^*_p \leq 0$; $\Lambda^*_{p^*} \geq 0$.

The entire discussion for wage rigidities, etc., in the home case applies in the "foreign" case as well.

Given the values of the two demand policy variables g and g^*, the two demand functions (17) and (25), and the supply functions equations (23) and (26) give us four equations in the variables y, y^*, P, P^*. These already include the restriction that the trade balance x is the same for both countries. Next we study the properties of this equilibrium by considering the effect of a demand increase dg in the home country.

Expansionary Demand Policy in One Country

We analyze the effect of expansionary demand policy in the home country under a variety of institutional assumptions concerning wage rigidity. It will be apparent that these have impacts on the results for the effectiveness of fiscal policy. The model is summarized in equations (17), (23), (25) and (26).

Totally differentiating these we obtain the following linear system:

(27)
$$\begin{bmatrix} 1 & 0 & -\Lambda_p & -\Lambda_p* \\ 0 & 1 & -\Lambda^*_p & -\Lambda^*_p* \\ 1 & 0 & -V_p & -V_p* \\ 0 & 1 & -V^*_p & -V^*_p* \end{bmatrix} \begin{bmatrix} dy \\ dy^* \\ dP \\ dP^* \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ V_g \\ 0 \end{bmatrix} dg.$$

The determinant is given by:

(28)
$$\Delta = (V_p - \Lambda_p)\ (V^*_p* - \Lambda^*_p*) - (V_p* - \Lambda_p*)\ (V^*_p - \Lambda^*_p).$$

This is the product of the own effects of price changes less the product of the cross effects. The discussion after equation (17) led us to notice that the own demand effects are larger than the cross demand effects. Furthermore, in general, the own supply effects are larger than or equal to the cross supply effects. Therefore, Δ can in general be taken to be positive.

The comparative status of the model of equation (27) following an increase in g are summarized below:

(29)
$$\frac{dy}{dg} = V_g[\Lambda_p*\ (V^*_p - \Lambda^*_p) - \Lambda_p(V^*_p* - \Lambda^*_p*)]/\Delta.$$

(30)
$$\frac{dy^*}{dg} = -V_g[\Lambda^*_p\ V^*_p* - V^*_p\ \Lambda^*_p*]/\Delta.$$

(31)
$$\frac{dP}{dg} = -V_g(V^*_p* - \Lambda^*_p*)/\Delta.$$

(32)
$$\frac{dP^*}{dg} = +V_g(V^*_p - \Lambda^*_p)/\Delta.$$

The numerator of equation (29) for dy/dg is essentially V_g times the own price effects less cross-price effects. Therefore in general we expect it to be positive. A major exception would be when home supply is insensitive to prices; then dy/dg = 0. The numerator of (30) contains only characteristics of the "foreign" country. When the foreign supply function is symmetric with respect to the two prices, the sign of dy^*/dg depends on the relative absolute values of the demand effects, and is therefore negative.[3/] We return to a detailed analysis of (29) and (30) below.

The condition that $\Delta > 0$ is required to obtain the result that an increase in g will increase both P and P^* in (31) and (32). If $\Delta < 0$, an increase in g will decrease P and P^*. The P, P^* solution for an increase in g is illustrated in Figure 3. There, the PP line is the combination of P and P^* that yields equilibrium in the home market. The equation for this line is:

$$(V_p - \Lambda_p)dP = -(V_{p^*} - \Lambda_{p^*})dP^* - V_g dg.$$

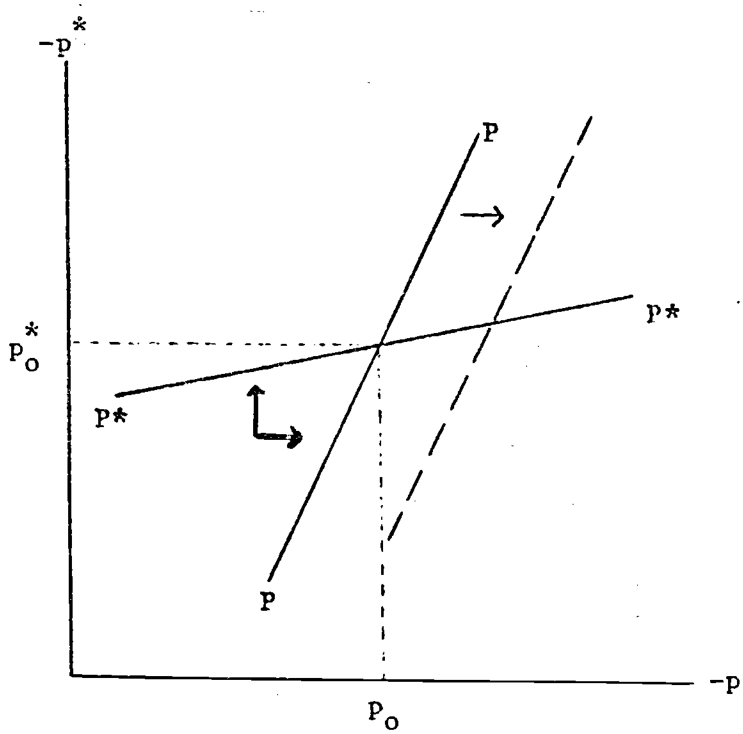
For a given g, the slope is $-(V_p - \Lambda_p)/(V_{p^*} - \Lambda_{p^*})$. The P^*P^* line is the combination of P and P^* that yields equilibrium in the foreign country. The equation for P^*P^* is $(V^*_p - \Lambda^*_p)dP = -(V^*_{p^*} - \Lambda^*_{p^*})dP^*$. If P^*P^* is flatter than PP then Δ is positive and an increase in g raises both prices along P^*P^* as in Figure 3. If P^*P^* were steeper than PP then an increase in g would lower both prices.

Effects on Real Output

In analyzing the comparative statics effects on y and y^* of a change in g, we will study the cases in which the "home" country has no money illusion, so that $\theta_p + \theta_{p^*} = 1$. Whether the real wage is rigid will effect only the size of the multipliers, with $g_N \leq 0$. For the "foreign" country we will vary the assumptions across several of the differing cases of wage rigidity distinguished earlier. These are:

[3/] This is the result obtained by Argy and Salop [1978].

FIGURE 3: Increase in g in 2-commodity model



1. Rigid nominal wages, with $\theta_p^* = \theta_p^{**} = 0$, and $\psi_p^* = 1$,

2. Rigid real wages, with $\theta_p^{**} \leq \psi_p^{**}$,

3. Rigid real wages, with $\theta_p^{**} > \psi_p^{**}$,

4. Sticky nominal wages, with $\theta_p^* + \theta_p^{**} < 1$.

Clearly this is only a small subset of the possible combinations of assumptions for wage behavior in both countries, as is obvious in equations (29) and (30).

The four cases are summarized in Table 3. In the first case, even with no money illusion at home, demand expansion increases home output through the differential effects of P and P^* on home supply. In Section II with one commodity and corresponding price, dy/dg = 0. This may be the proper case to associate with Giersch.

An important thing to note about cases 2 and 3 is that our results are completely classical when, in any country, workers and firms are equally sensitive to the home price level: $\theta_p^{**} = \psi_p^{**}$. In this case expansionary policy in either country will not affect supply in that country.

If the foreign country (i.e., the one that does not expand) has a fixed real wage while workers are more sensitive to the cross price than are firms (case 2), the expansion at home is contractionary abroad. This result is the one obtained by Argy and Salop, Sachs, and Bruno and Sachs. However, there are two caveats to this result. These are shown in cases 3 and 4. Enough money illusion in the foreign country will make the increase in g expansionary there, as in case 4. By "enough" we mean that

$$(33) \qquad \theta_p^* + \theta_p^{**} < 1 - \frac{(\psi_p^{**} - \theta_p^{**})(V_p^* + V_p^{**})}{V_p^{**}} .$$

TABLE 3: Effects of Demand Expansion on Output

ASSUMPTIONS ON WAGE BEHAVIOR			EFFECTS ON OUTPUTS		
Home		Foreign	dy/dg		dy^*/dg
No money illusion ($\theta_p < \psi_p$)	(1)	Rigid nominal wage $\theta_p^* = \theta_p^{**} = 0$; ($\psi_p^{**}=1$)	+	(Giersch case)	+
same	(2)	Rigid real wage $\theta_p^{**} < \psi_p^{**}$	+	(Argy-Salop case)	−
		$\theta_p^{**} = \psi_p^{**}$	+	(classical case)	0
same	(3)	Rigid real wage $\theta_p^{**} > \psi_p^{**}$	+	(Hong Kong)	+
same	(4)	Sticky money wage $\theta_p^* + \theta_p^{**} < 1$	+	(Keynesian case)	(+)

In general the RHS of (33) will be close to unity since (a) $V_p^* + V_p^{**}$ is small relative to V_p^{**}, and (b) $(\psi_p^{**} - \theta_p^{**})$ is between minus one and one. Therefore it takes but a little money illusion to reverse the contractionary effect abroad of an increase in g at home. A final caveat is that if in the foreign country firms are more sensitive to the cross price than are workers, a rare case of which Hong Kong may be an example, then our increase in g is expansionary abroad.

IV. Empirical Results on Money Illusion and Wage Rigidity

To test for the existence of money illusion or wage rigidity we begin by specifying a labor supply equation making the level of the nominal wage dependent on the expected price level and a measure of labor demand. A time trend is added to account for productivity growth and trends in the variables. An estimating form of this static model would be

$$(34) \qquad \ell n\, W_t = \alpha_0 + \alpha_1\, \ell n\, P_t^e + \alpha_2\, \ell n\, D_t + \alpha_3 t + \varepsilon_t.$$

Here P^e represents the expected price level, D is a measure of labor demand, proxied below by real GNP, and the time trend is included to detrend W, P, and D.

If the coefficient α_1 were unity, money illusion would be absent and the real-wage cases of Sections II and III with $\theta_p + \theta_p{}^* = 1$ are relevant. If in addition α_2 is insignificant, the real wage would be rigid in the relevant period and $g_N = 0$ in Sections II and III. If α_1 were less than unity, money illusion exists ($\theta_p + \theta_p{}^* < 1$), and the extreme case would have $\alpha_1 = 0$.

Estimation of (34) directly would assume that wages adjust within a quarter to changes on their determinants. The literature on wage equations shows clearly that this is not the case. We have estimated equations in the form of (34), and observed generally quite significant serial correlation in the residuals. These equations using instrumental variables for P^e and D, as described in detail below, and the Cochrane-Orcutt adjustment for serial correlation, are shown in Appendix B. The first-order serial correlation coefficients ρ are generally in the .7 to .9 range, and the U.K. shows evidence of higher-order correlation. This can be taken as evidence that there is a lagged adjustment process moving wage rates, adjusting the average wage toward the static supply of labor schedule, whatever its slope. This friction could be due to the existence of long-term (more than one quarter) contracts, in nominal or real terms.

In a dynamic context we wish to test whether the adjustment process is in terms of real or nominal wages, and how sensitive it is to demand conditions. Thus the question is whether it is today's real wage that depends on past real wages and current labor market conditions or today's nominal wage that depends on past nominal wages and current labor market conditions. The former adjustment mechanism (which results for instance from indexed contracts) implies that our model is neutral to fiscal policy in the absence of terms of trade effects. The latter corresponds to the presence of "money illusion."

Let us reinterpret the static supply of labor function in equation (34) as giving the target wage W^*:

$$\ell n\ W_t^* = \ell n\ P_t^e + \alpha_1\ \ell n\ D_t + \alpha_2 t + \varepsilon_t. \tag{35}$$

We consider only models of the partial adjustment type. Nominal wage stickiness is given by:

$$\ell n(W_t/W_{t-1}) = \lambda(\ell n\ W_t^*/W_{t-1}). \tag{36}$$

Real wage stickiness is given by:

$$\ell n\ (W_t/P_t^e) - \ell n\ (W_{t-1}/P_{t-1}) = \mu \cdot [\ell n\ (W_t^*/P_t^e) - \ell n\ (W_{t-1}/P_{t-1})]. \tag{37}$$

These two equations lead to two different short-run supply of labor schedules. Using (35) and (36) we obtain for the nominal case,

$$\ell n\ (W_t/P_t^e) = (\lambda-1)\ \ell n(P_t^e/W_{t-1}) + \lambda\alpha_1\ \ell n\ D_t + \lambda\alpha_2 t + \lambda\varepsilon_t. \tag{38}$$

Using (35) and (37) we obtain for the real-wage case,

$$\ell n\ (W_t/P_t^e) = (1-\mu)\ \ell n\ (W_{t-1}/P_{t-1}) + \mu\alpha_1\ \ell n\ D_t + \mu\alpha_2 t + \mu\varepsilon_t. \tag{39}$$

These two models are nonnested. We can embed both hypotheses in a more "general" adjustment mechanism which combines (36) and (37) in the following manner:

$$(40) \qquad \ell n\ (W_t/W_{t-1}) = \gamma_1\ \ell n\ (W_t^*/W_{t-1}) + \gamma_2\ \ell n\ (P_t^e/P_{t-1}).$$

Here if $\gamma_2 = 0$, we have equation (36) representing nominal wage adjustment; if $\gamma_2 = 1 - \gamma_1$ we have equation (37) instead. Substituting (36) for W^* into (40) we obtain the estimating equation:

$$(41) \qquad \ell n\ (W_t/P_t^e) = (\gamma_1+\gamma_2-1)\ \ell n\ (P_t^e/W_{t-1}) + \gamma_2\ \ell n\ (W_{t-1}/P_{t-1})$$

$$+ \gamma_1\alpha_1\ \ell n\ D_t + \gamma_1\alpha_2 t + \gamma_1\varepsilon_t.$$

This is the common alternative hypothesis against which we test (38) and (39). We can compare the three equations directly. If $\gamma_2 = 0$, γ_1 in (41) is equal to λ in (38); if $\gamma_2 = 1-\gamma_1$, then γ_2 is also equal to $(1-\mu)$ in equation (39).

We reject the hypothesis that it is the real wage that adjusts according to equation (37) if the coefficient on $\ell n(P_t^e\ /\ W_{t-1})$ is significantly different from zero. On the other hand we reject equation (36) if the estimate of γ_2 in (41) is significantly different from zero. Of course the models are indistinguishable when the adjustment is instantaneous, i.e., $\gamma_1 = 1$, $\gamma_2 = 0$.

The estimating equation (41) is derived from specification of an equation for the <u>level</u> of the nominal wage, (34) or (35), dependent on the <u>level</u> of demand, and a standard adjustment mechanism. This is a different procedure from that followed by Bruno and Sachs [1979][4/], Gordon [1977], and Spitaeller

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[4/] Bruno and Sachs' 1979 specification involves a partial adjustment of the <u>rate of change</u> of wages to the equilibrium rate of change of wages which depends on GNP. This leads to an equation similar to (41). We are working on a paper that tests their specification directly against our "real" and "nominal" wage adjustment models.

[1976]. In particular, their specification assumes that the level of demand affects the rate of change of wages, while a simple differencing of equation (41) would put the change in demand into the equation for the change in the wage rate. This difference must be kept in mind in interpreting our results below.

In estimating equation (41) for five major OECD countries, we used price data from the OECD Main Economic Indicators and GNP data from the International Financial Statistics published by the IMF. The D_t variable is real GNP for all countries except Italy where it is real GDP. The dependent variable is hourly compensation, provided by the IMF.[5/] The price variable is the Consumer Price Index. All variables were seasonally adjusted using the X-11 method.

We estimated all equations using instrumental variable estimates for P^e and GNP. For each country regressions were performed of the CPI and GNP on four lagged values of CPI and GNP plus the current and four lagged values of the money stock. Fitted values from these regressions were used in the wage equation for P^e and GNP. These are denoted as $\hat{P}$ and $\widehat{GNP}$ in Table 4 below. This procedure can be interpreted econometrically as eliminating the simultaneity bias running from the real wage to GNP and the CPI, or as imposition of rational expectations on the wage equation.

We estimated equation (41) with quarterly observations for two periods, one running from 1961 to 1978, the other from 1971 to 1978. This was done because the latter period exhibits a higher rate of inflation and it is likely that workers are more sensitive to the price level when its increases are larger. Furthermore, the period 1971-1978 saw a large increase in oil

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[5/] We also estimated the equations using hourly earnings and the hourly wage as dependent variables. The results are virtually identical to those using compensation data and are available upon request.

prices which should have led to a reduction in the equilibrium real wage, therefore making this an ideal period to test the rigidity of the real wage. Equations in Phillips curve form have been estimated for the period 1958-73 quarterly by Gordon, for the period 1957-72 semiannually by Spitaeller, and for the period 1962-76 annually by Bruno and Sachs.

The estimates of equation (41) are shown in Table 4. In all cases the dependent variable is $\hat{W_t/P_t}$. There are two equations for each country, one for the full period 1961-78, and one for the shorter period 1971-78. The coefficients are presented with their standard errors in parentheses. In the last column of the table we give the result of the test of real versus nominal wage adjustment. R means that the real wage hypothesis is accepted and the nominal hypothesis is rejected, and vice versa for N. The R, N entries signify that neither hypothesis can be rejected.

The first thing we notice in Table 4 is that the coefficient of the demand variable $\hat{GNP}$ is significantly positive in all countries for the full period, but insignificant for 1971-78. This says that in each of these countries wage movements became less sensitive to demand variation in the 1970s than earlier; in terms of our theoretical model $g_N = 0$.

Turning to the real vs. nominal wage issue, we see that the U.S. is the only country where the nominal adjustment model dominates. The coefficient of W_{t-1}/P_{t-1} is effectively zero for both periods, and the estimate of the λ adjustment coefficient in the money wage model is approximately 0.7. This result is consistent with the earlier findings of Bruno-Sachs [1979], Gordon [1977] and Spitaeller [1976]. The U.K. regressions yield ambiguous results. The nominal wage model is rejected over the full period, but neither hypothesis can be rejected in the 1971-78 period. On the presumption that the real wage model is accepted, the estimate of the μ adjustment coefficient is approximately 0.45 over both periods. This fits the results of Bruno-Sachs, but

Table 4: Tests of Real vs. Nominal Adjustment of Wages Using Hourly Compensation Data
(Dependent Variable = $\ell n\ (W_t/\hat{P}_t)$)

		EXPLANATORY VARIABLES							
OUNTRY	TIME PERIOD	$\hat{P}/W_{t-1}$	W_{t-1}/P_{t-1}	$\hat{GNP}_t$	TIME	C	DW	R^2	R vs. N
.S.	61:2 - 78:4	-.69 (.15)	-.06 (.20)	.07 (.02)	.0011 (.0002)	-.06 (.20)	1.9	.99	N
	71:1 - 78:4	-.74 (.20)	-.19 (.31)	.07 (.05)	.001 (.0003)	.01 (.24)	1.8	.98	N
.K.	61:2 - 78:3	-.47 (.24)	.56 (.21)	.10 (.06)	-.0007 (.0006)	-.34 (.19)	1.3	.99	R
	71:1 - 78:3	-.50 (.39)	.55 (.31)	.26 (.17)	-.001 (.001)	-.85 (.50)	1.3	.95	R, N
APAN	61:2 - 78:4	.77 (.42)	1.49 (.37)	.14 (.04)	.0022 (.0011)	-1.38 (.39)	2.7	.99	R
	71:1 - 78:4	1.04 (.71)	1.67 (.64)	.0028 (.18)	.0040 (.0024)	.36 (2.10)	2.6	.93	R
TALY	61:2 - 78:3	.34 (.36)	1.27 (.33)	.16 (.08)	-.001 (.001)	-1.73 (.83)	2.4	.99	R
	71:1 - 78:3	.43 (.67)	1.34 (.65)	-.12 (.25)	.001 (.002)	1.58 (2.88)	2.6	.97	R
ERMANY	61:2 - 78:4	-.53 (.76)	.35 (.73)	.13 (.05)	.0003 (.001)	-.71 (.33)	2.2	.99	N, R
	71:1 - 78:4	2.27 (1.58)	3.01 (1.49)	-.05 (.17)	.0038 (.0028)	.49 (1.18)	2.7	.98	R

not Spitaeller.

For Japan and Italy, the nominal wage model is rejected for both periods. The W_{t-1}/P_{t-1} coefficient is insignificantly different from unity in all four regressions, suggesting a long adjustment process with μ close to zero. These results are roughly consistent with the literature.

For Germany, neither hypothesis can be rejected for the full period, but the nominal wage model is rejected for 1971-78. As in Italy and Japan, the μ estimate is close to zero. These results are also roughly consistent with the literature. Gordon and Spitaeller found money illusion in earlier data sets ending in 1972 and 1973, respectively, and Bruno-Sachs reject it on data through 1976.

In summary, it seems that sensitivity of wage movements to fluctuations in demand has been reduced sharply in the 1970s relative to the earlier period in all five countries. The U.S. is the only country in which the model of nominal wage stickiness is supported; in the U.K., Japan, Italy and Germany it is the real wage that adjusts slowly. This is consistent with effective indexation in these countries as compared with the U.S.

In terms of the model in Sections II and III, only the U.S. seems to have enough money illusion to bring about an expansion in response to third country increases in demand. On the other hand, money illusion appears to be absent in the U.K., Germany, Italy, and Japan. This means that these countries may have to worry about the effect of expansionary fiscal policy in the other countries.

APPENDIX A

Consider a discriminating monopolist producing in the home country and selling in two countries. He faces the following problem

$$\text{Max } \{p(q) \cdot q + p^*(q^*, u)q^* - W \cdot \eta(q+q^*)\},$$

where $p(q)$ and $p^*(q^*)$ are the inverse demand functions, η the employment function with $\eta' > 0$, $\eta'' > 0$ and u a shift parameter such that for a higher u the foreigners are willing to pay more for each quantity q^*. $p^*_u > 0$. We assume further $p^*_{uq^*} = 0$. His first order conditions are:

$$p_q \cdot q + p = W\eta' \ ;$$

$$p^*_{q^*}q^* + p^* = W\eta' \ .$$

Totally differentiating with a change in u gives us

$$(p_{qq}q + 2p_q) \ dq - W\eta''(dq + dq^*) = 0 \ ;$$

$$(p^*_{q^*q^*}q^* + 2p^*_{q^*}) \ dq^* - W\eta''(dq + dq^*) = -p^*_u \ du.$$

Assuming $p_{qq} = p_{q^*q^*} = 0$, we obtain:

$$\begin{bmatrix} 2p_q - W\eta'' & -2p_q \\ -W\eta'' & 2p^*_{q^*} \end{bmatrix} \begin{matrix} (dq + dq^*) \\ (dq^*) \end{matrix} = \begin{bmatrix} 0 \\ -p^*_u du \end{bmatrix},$$

which leads to $\dfrac{dq + dq^*}{du} > 0$,

$$\frac{dq^*}{du} > 0.$$

This means that an increase in demand in any one country leads to an increase in demand for labor by the firm. We have written this as a demand-for-labor function that depends on both prices.

APPENDIX B

Estimates of Static Wage Equations

(Dependent Variable = $\ell n\ W_t$)

		EXPLANATORY VARIABLES						
COUNTRY	TIME PERIOD	$\hat{P}$	$\widehat{GNP}$	T	C	ρ	DW	R^2
U.S.	61:2 - 78:4	.90 (.06)	.06 (.07)	.005 (.001)	.62 (.47)	.76 (.08)	2.1	.99
	71:1 - 78:4	.29 (.16)	-.13 (.09)	.018 (.003)	1.17 (.55)	.81 (.11)	1.9	.99
U.K.	61:2 - 78:3	.59 (.12)	.29 (.16)	.019 (.004)	-.45 (.42)	.95 (.04)	1.4	.99
	71:1 - 78:3	.50 (.23)	.21 (.29)	.024 (.010)	-.52 (.77)	.91 (.08)	1.1	.99
JAPAN	61:2 - 78:4	.81 (.25)	.17 (.18)	.018 (.007)	-1.38 (1.77)	.91 (.05)	2.6	.99
	71:1 - 78:4	1.99 (.14)	1.06 (.18)	-.024 (.005)	-9.37 (1.95)	.14 (.18)	2.3	.99
ITALY	61:2 - 78:3	.80 (.17)	-.002 (.22)	.020 (.006)	.53 (2.38)	.94 (.04)	2.3	.99
	71:1 - 78:3	.80 (.31)	-.11 (.32)	.016 (.014)	2.09 (3.65)	.88 (.09)	2.6	.99
GERMANY	61:2 - 78:4	1.40 (.22)	.37 (.12)	.006 (.003)	-1.50 (.68)	.83 (.07)	2.3	.99
	71:1 - 78:4	2.10 (.33)	.17 (.27)	-.003 (.005)	.54 (1.60)	.50 (.16)	2.1	.99

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