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*Estimated Inflation Costs Had European Unemployment Been Reduced in the 1980s by Macro Policies**

This paper uses a multicountry econometric model to estimate what the inflation costs would have been had German monetary policy reduced European unemployment in the 1982:*i*–1990:*iv* period. A "non-NAIRU" framework is proposed for thinking about these costs.

1. Introduction

If macroeconomic policies had lowered European unemployment in the 1980s, what would have been the inflation costs? Under the standard view of the long-run unemployment-inflation relationship, this is not an interesting question. The standard view is that there is a value of the unemployment rate (the NAIRU) below which the price level accelerates and above which the price level decelerates. This view is echoed, for example, in *Unemployment: Choices for Europe,* where Alogoskoufis et al. (1995, 124) state, "We would not want to dissent from the view that there is no long-run trade-off between activity and inflation, so that macroeconomic policies by themselves can do little to secure a lasting reduction in unemployment." Under the standard view it is not sensible to talk about long-run trade-offs between unemployment and inflation.

The results in Fair (1997, 1998), however, which are based on estimating price and wage equations for 28 countries, including 15 European countries, do not support the NAIRU model. They overwhelmingly reject the dynamics implied by the model. The results support the "level" form of the price and wage equations, where a permanent change in the unemployment rate has a long-run effect on the price level but not on the inflation rate (and not *a fortiori* on the change in the inflation rate). If these results are correct, they change the way one thinks about the trade-off between

*All the data used in this paper can be downloaded from the website http://fairmodel.econ.yale.edu. Also, the experiment performed in this paper can be duplicated on the website.

0164-0704/99/$1.50

unemployment and inflation, and they make the question about macro policies and European unemployment an interesting one.

This paper uses the multicountry econometric (MC) model in Fair (1994), including the price and wage equations mentioned above, to estimate what would have happened to European unemployment and inflation in the 1982:*i*–1990:*iv* period had the Bundesbank followed an easier monetary policy than it in fact did. The MC model is outlined in Section 2, and the price and wage equations are presented and discussed in Section 3. The results of the experiment are then reported in Section 4.

If the NAIRU model is rejected, the new story about the price level and unemployment does not have to imply that unemployment can be driven close to zero with only a modest long-run effect on the price level. There may be (and seems likely to be) a nonlinear relationship between the price level and unemployment at low values of unemployment, where pushing unemployment further and further below some low value results in larger and larger increases in the price level. This nonlinearity would in effect bound unemployment above a certain value. It will be seen in Section 3 that this nonlinearity is hard to estimate because there are not enough observations at low unemployment rates to provide good estimates. This paucity of observations argues against using estimated price and wage equations to predict what prices and wages would be at unemployment rates much lower than those that existed historically. Fortunately, this is not a problem for the present paper because the period considered here is one characterized by high unemployment rates. More will be said about this in the Conclusion.

2. The MC Model

There are 33 countries in the MC model.[1] There are 31 stochastic equations for the United States and up to 15 each for the other countries. The total number of stochastic equations is 328, and the total number of estimated coefficients is 1442. In addition, there are 1041 estimated trade-share equations. The total number of endogenous and exogenous variables, not counting the trade shares, is about 4000. Trade-share data were collected for 45 countries, and so the trade-share matrix is 45×45.[2] An updated

[1]The 33 countries are the United States, Canada, Japan, Austria, France, Germany, Italy, the Netherlands, Switzerland, the United Kingdom, Finland, Australia, South Africa, Korea, Belgium, Denmark, Norway, Sweden, Greece, Ireland, Portugal, Spain, New Zealand, Saudi Arabia, Venezuela, Colombia, Jordan, Syria, India, Malaysia, Pakistan, the Philippines, and Thailand.

[2]The 12 other countries that fill out the trade-share matrix are Nigeria, Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, the United Arab Emirates, Israel, Bangladesh, Singapore, and an all other category.

version of this model has been used for the present work, and this version is presented on the website mentioned in the introductory footnote.

The estimation periods begin in 1954:*i* for the United States and as soon after 1960 as data permit for the other countries. They end between 1992 and 1994 except for the United States, where they end in 1997:*i*. The estimation technique is 2SLS except when there are too few observations to make the technique practical, where OLS is used. The estimation accounts for possible serial correlation of the error terms. The variables used for the first stage regressors for a country are the main predetermined variables in the model for the country. A list of these variables is available from the website.[3]

On the demand side, there are estimated equations for consumption, fixed investment, inventory investment, and imports for each country. Consumption depends on income, wealth, and an interest rate. Fixed investment depends on output and an interest rate. Inventory investment depends on the level of sales and the lagged stock of inventories. The level of imports depends on income, wealth, the relative price of imported versus domestically produced goods, and an interest rate. The interest rate used for a given country and equation is either a short-term rate or a long-term rate, depending on which was more significant. The long-term rate is related to the short-term rate in each country through a standard term structure equation, where the long-term rate depends on the current value and lagged values of the short-term rate. A decrease in the short-term interest rate in a country leads to a decrease in the long-term rate, and interest-rate decreases have a positive effect on consumption, fixed investment, and imports.

There are estimated price and wage equations per country. The domestic price level in a country depends, among other things, on a measure of demand pressure (usually an output-gap variable) and the price of imports. These equations are presented in Section 3.

There is an estimated interest-rate reaction function for each country. The short-term interest rate depends on inflation, demand pressure, and the current account. These are "leaning against the wind" equations of the monetary authorities. The monetary authorities are estimated to raise short-term interest rates in response to increases in inflation and demand pressure and decreases in the current account. The U.S. short-term interest rate is an explanatory variable in a number of the other countries' reaction functions. This means that the United States is assumed to play a leadership role in

[3]All the variables and equations in the model are presented in Appendices A and B of *The MC Model Workbook* on the website. All the coefficient estimates are presented in the "Chapter 5 Tables" and "Chapter 6 Tables" that follow the appendices. Various test results for each equation are presented along with the coefficient estimates.

setting monetary policy. Also, the German short-term interest rate is an explanatory variable in a number of the other European countries' reaction functions.

There is an estimated exchange rate equation per country. For Germany and all the non-European countries, the dependent variable is the exchange rate vis-à-vis the U.S. dollar. For these countries, the exchange rate depends on the price level of the country relative to the U.S. price level and the short-term interest rate of the country relative to the U.S. interest rate. For the European countries except Germany, the dependent variable is the exchange rate vis-à-vis the mark. For these countries the exchange rate depends on the price level of the country relative to the German price level and the short-term interest rate of the country relative to the German interest rate.

There are also estimated equations explaining employment, the labor force of men, and the labor force of women per country. Employment depends on output and the amount of excess labor on hand. Labor force participation depends on the real wage and a labor market tightness variable designed to pick up discouraged worker effects.

In a given trade-share equation, the share of country i's total imports imported from country j depends on the price of country j's exports relative to a price index of all the other countries' export prices. The trade-share equations are in U.S. dollars, and all export prices are converted to dollar prices using the exchange rates. The restriction that the sum of all exports equals the sum of all imports is imposed in the model.

There is a mixture of quarterly and annual data in the MC model. Quarterly equations are estimated for 14 countries (the first 14 in footnote 1), and annual equations are estimated for the remaining 19. However, all the trade-share equations are quarterly. There are quarterly data on all the variables that feed into the trade-share equations, namely the exchange rate, the local-currency price of exports, and the total value of imports per country. When the model is solved, the predicted annual values of these variables for the annual countries are converted to predicted quarterly values using a simple distribution assumption. The quarterly predicted values from the trade-share equations are converted to annual values by summation or averaging when this is needed.

3. The Price and Wage Equations

Empirical Specification

The theory that has guided the specification of the price and wage equations in this section was first presented in Fair (1974), and more recent discussions are in Fair (1984, Chap. 3), Fair (1994, Chap. 2), and Fair (1998). The empirical specification of the price and wage equations is as follows:

$$p_t = \beta_0 + \beta_1 p_{t-1} + \beta_2(w_t - \lambda_t) + \beta_3 s_t + \beta_4 D_t + \beta_5 t + \epsilon_t \;; \quad (1)$$

$$w_t - \lambda_t = \gamma_0 + \gamma_1(w_{t-1} - \lambda_{t-1}) + \gamma_2 p_t + \gamma_3 p_{t-1} + \gamma_4 D_t + \gamma_5 t + \mu_t \;; \quad (2)$$

p is the log of the price level; w is the log of the wage rate; s is the log of the import price level divided by p lagged once—it is a measure of relative import prices; D is some measure of demand pressure—the choices tried for D are discussed below; and λ is the log of Λ, where Λ is an estimate of the potential level of output per worker. In the empirical work Λ is estimated from peak-to-peak interpolations of output per worker. The growth rate of Λ is an estimate of the growth rate of potential productivity. The change in $w - \lambda$ is the growth rate of the nominal wage rate less the growth rate of potential productivity. ϵ and μ are error terms.

The lagged price variable in Equation (1) can be thought of as picking up expectational effects, the wage variable and the relative import price variable as picking up cost effects, and the demand variable as picking up demand effects. All these effects are in the theoretical specification mentioned above.

The time trend in Equation (1) is meant to pick up any trend effects on the price level not captured by the other variables. Adding the time trend to an equation like (1) is similar to adding the constant term to an equation specified in terms of changes rather than levels. The time trend will also pick up any trend mistakes made in constructing λ_t. If, for example, $\lambda_t = \lambda_t^a + \theta t$, where λ_t^a is the correct variable to subtract from w_t to adjust for potential productivity, then the time trend will absorb this error.

In the wage equation, Equation (2), the wage rate is a function of the lagged wage rate, the current and lagged price level, the demand variable, and the time trend. It is an equation in which the wage rate adjusts to the price level over time. The price equation is identified because of the inclusion of the lagged wage in the wage equation, and the wage equation is identified because of the inclusion of the relative import price variable in the price equation.

When price and wage equations are specified, one has to be careful regarding what they imply about the determination of the real wage, which is $w_t - \lambda_t - p_t$ in the present notation. Solving Equations (1) and (2) for $w_t - \lambda_t - p_t$ yields:

$$
\begin{aligned}
w_t - \lambda_t - p_t = \frac{1}{1 - \beta_2\gamma_2} \{ & (1 - \beta_2)\gamma_1(w_{t-1} - \lambda_{t-1}) \\
& + [(1 - \beta_2)\gamma_3 - (1 - \gamma_2)\beta_1]p_{t-1} - (1 - \gamma_2)\beta_0 + (1 - \beta_2)\gamma_0 \\
& - (1 - \gamma_2)\beta_3 s_t - [(1 - \gamma_2)\beta_4 D_t + (1 - \beta_2)\gamma_4] \\
& - [-(1 - \gamma_2)\beta_5 + (1 - \beta_2)\gamma_5]t - (1 - \gamma_2)\epsilon_t \\
& + (1 - \beta_2)\mu_t\} \, . \qquad (3)
\end{aligned}
$$

Unless the coefficient of $w_{t-1} - \lambda_{t-1}$ equals the negative of the coefficient of p_{t-1}, Equation (3) implies that in the long run the real wage depends on the level of p, which is not sensible. Consequently, the restriction that the two coefficients are equal in absolute value and of opposite signs is imposed in the estimation. The restriction on the structural coefficients is

$$
\gamma_3 = \frac{\beta_1}{1 - \beta_2}(1 - \gamma_2) - \gamma_1 \, . \qquad (4)
$$

The Demand Pressure Variable, D

An attempt was made in the estimation of the price and wage equations to account for a possible nonlinear relationship between p_t and the unemployment rate at low levels of the unemployment rate. Two functional forms were tried for the unemployment rate. In addition, two other activity variables, both measures of the output gap, were tried in place of the unemployment rate, and two functional forms were tried for each gap variable.

Let u_t denote the unemployment rate, and let $u_t' = u_t - u^{min}$, where u^{min} is the minimum value of the unemployment rate in the sample period ($t = 1, \ldots, T$). The first form tried was linear, namely $D_t = u_t'$. The other was $D_t = 1/(u_t' + 0.02)$. For the second form D_t is infinity when u_t' equals -0.02, and so this form says that as the unemployment rate approaches 2.0 percentage points below the smallest value it reached in the sample period, the price level approaches infinity.[4]

For the first output-gap variable, a potential output series, denoted Y_t^*, was constructed from peak-to-peak interpolations of the level of output per worker and the number of workers per working-age population. (The

[4]In earlier work values other than 0.02 were tried for D_t, including 0.005, 0.01, 0.015, and 0.05. The value that resulted in the best fit for a country tended to be around 0.02, and so for present purposes the formal searching was done using only 0.02 and the linear form. As discussed below, the fits tend to be similar across functional forms, and the data do not discriminate well among different forms, including the linear form.

peak-to-peak interpolation of output per worker is Λ_t mentioned above.) Define the gap, denoted G_t, as $(Y_t^* - Y_t)/Y_t^*$, where Y_t is the actual level of output, and let $G_t' = G_t - G^{min}$, where G^{min} is the minimum value of G_t in the sample period. For this variable the first form was linear, and the other was $D_t = 1/(G_t' + 0.02)$.

For the second output-gap variable, a potential output series was constructed by regressing, over the sample period, $\log Y_t$ on a constant and t. The gap G_t is then defined to be $\widehat{\log Y_t} - \log Y_t$, where $\widehat{\log Y_t}$ is the predicted value from the regression. The rest of the treatment is the same as for the first output-gap variable.

Two functional forms for the unemployment rate and two each for the output-gap variables yields 6 different variables to try. In addition, each variable was tried both unlagged and lagged once separately, giving 12 different variables. The searching was done using Equation (1) under the assumption of a first-order autoregressive error term and with three variables added. The three added variables are p_{t-2}, $w_{t-1} - \lambda_{t-1}$, and s_{t-1}. The demand pressure variable chosen was the one with the highest t-statistic. No demand pressure variable was chosen if the coefficient estimates of all the demand pressure variables were of the wrong sign.

Once the demand pressure variable was chosen, three further specification decisions were made. The first is whether $w_t - \lambda_t$ or $w_{t-1} - \lambda_{t-1}$ should be included in the final specification, the second is whether s_t or s_{t-1} should be included, and the third is whether the autoregressive assumption about the error term should be retained. For each of the first two decisions the variable with the higher t-statistic was chosen provided its coefficient estimate was of the expected sign, and for the third decision the autoregressive assumption was retained if the autoregressive coefficient estimate was significant at the 5% level. If when tried separately both $w_t - \lambda_t$ and $w_{t-1} - \lambda_{t-1}$ had coefficient estimates of the wrong sign, neither was used, and similarly for s_t and s_{t-1}.[5]

The same searching for the best demand pressure variable was done for the wage Equation (2) as was done for the price equation. This searching was done without imposing the coefficient restriction in (4) and under the assumption of a first-order autoregressive error term. Once the demand pressure variable was chosen, one further specification decision had to be made for the wage equation, namely whether the autoregressive assumption of the error term should be retained. The same decision criterion was used here as was used for the price equation.

[5]When $w_{t-1} - \lambda_{t-1}$ is chosen, the coefficient restriction in (4) becomes $\gamma_3 = (\beta_1 + \beta_2)(1 - \gamma_2) - \gamma_1$.

The Estimates

The estimation technique was 2SLS for the quarterly countries and OLS for the annual countries. For 2SLS, the endogenous variables were taken to be p_t, w_t, D_t, and s_t. The quality of the data varies across countries, and the results for the individual countries should not necessarily be weighted equally. In particular, the results for the countries with only annual data should probably be weighted less. Also, the wage data are probably not in general as good as the price data. The reason there are fewer countries with estimated wage equations than estimated price equations below is simply because of data limitations.

Four dummy variables were used for Germany for all its estimated equations in an attempt to account for the effects of the reunification of the country. The first had a value of one in 1990:*iii* and zero otherwise; the second a value of one in 1990:*iv* and zero otherwise; the third a value of one in 1991:*i* and zero otherwise; and the fourth a value of one in 1991:*ii* and zero otherwise. To save space, the coefficient estimates for the dummy variables have not been reported in the tables below.

The estimates of the final specification of the price equation are presented in Table 1.[6] The table shows that, of the 18 countries for which a demand pressure variable was used,[7] the functional form was linear for 10 of them. The chosen variable was the unemployment rate for 4 of them, the first output-gap variable for 8 of them, and the second output-gap variable for the remaining 6. There is thus no strong pattern here, although there is a slight edge for the linear form and the first output-gap variable. The good showing for the linear form shows the difficulty of estimating the point at which the relationship between the price level and demand becomes nonlinear. Also, although not shown in Table 1, the fits of the equations tended not to be very sensitive to the use of alternative functional forms, such as those mentioned in footnote 4, and no clear winner emerged.

Of the 9 countries with no demand pressure variable in Table 1, two of them—the Netherlands and the United Kingdom—have wage equations with demand pressure variables. For these two countries demand pressure affects prices by affecting wages, which affect prices. South Africa is the only quarterly country for which there are no demand pressure effects on the price level.

The relative import price variable, s_t, does well in Table 1. All 27 coefficient estimates are positive, and 19 estimates have t-statistics greater

[6]The estimates of the price and wage equations for the United States are not presented in this paper. See Fair (1998) and the website for a detailed discussion of the U.S. results.

[7]Remember, no demand pressure variable was included if the coefficient estimates of all the demand pressure variables were of the wrong sign.

than 2.0. The wage rate also does fairly well. Of the 17 estimates in Table 1, 12 have t-statistics greater than or equal to 2.0.

The estimates of the final specification of the wage equation are presented in Table 2. The coefficient restriction (4) was imposed for all these estimates. Of the 11 countries for which a demand pressure variable was used, the functional form was linear for 7 of them. The chosen variable was the unemployment rate for 4 of the 11 and the second output-gap variable for the other 7. There is thus an edge for the linear form and the second output-gap variable. The good showing for the linear form further shows the difficulty of estimating nonlinearities between demand pressure and price and wage levels.

Tests of the Equations

A key question about the specification of the price and wage equations in (1) and (2) is whether the true dynamics of the price and wage processes have been adequately captured. To examine this, various lagged values of the variables in the equations have been added to the equations and χ^2 tests of their joint significance performed. The error terms have also been tested for fourth-order serial correlation. The implicit expectations mechanism has been tested by adding the *led* value of the wage rate to the price equation and testing for its significance. This is one way of testing the rational expectations hypothesis. The coefficient restriction in (4) has been tested. Finally, a stability test of the coefficients has been performed. The results of these tests are presented in Fair (1997), and this discussion will not be repeated here. The equations do fairly well in these tests. In particular, the extra lagged values are generally not significant, which is fairly strong support of the dynamics. If the equations had bad dynamics, one would expect the additional lagged values to be significant.

A Digression on the NAIRU Specification

It is of interest to see how the price and wage Equations (1) and (2) compare to the NAIRU specification. Although there are many different versions of the NAIRU specification, the following equation encompasses most versions:

$$\pi_t = \sum_{i=1}^{n} \delta_i \pi_{t-i} - \beta(u_t - u_t^*) + \theta s_t + \nu_t , \qquad \sum_{i=1}^{n} \delta_i = 1 , \tag{5}$$

where π_t is the rate of inflation ($\pi_t = p_t - p_{t-1}$, where p is the log of the price level), u_t is the actual value of the unemployment rate, u_t^* is the NAIRU, s_t is a supply shock variable, and ν_t is the error term. In the simplest

TABLE 1. *Estimates of the Price Equation,* $p_t = \beta_0 + \beta_1 p_{t-1} + \beta_2(w_t - \lambda_t) + \beta_3 s_t + \beta_4 D_t + \beta_5 t$

	Best D	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\rho}$	*SE*	*DW*	*Sample*
Quarterly											
CA	$G2_{-1}$(lin)	−0.070	0.947	0.012	0.021	[a]−0.13469	0.00047	0.499	0.0053	2.25	1966:*i*–1996:*i*
		(−0.67)	(17.53)	(0.25)	(1.44)	(−5.16)	(1.99)	(5.43)			
JA	$G2$(lin)	−0.765	0.742	0.139	0.028	−0.24050	0.00152	0.688	0.0074	2.15	1967:*iii*–1995:*iv*
		(−3.09)	(10.23)	(2.73)	(2.06)	(−3.36)	(3.07)	(7.06)			
AU	$G1$(0.02)	−0.734	0.840	[a]0.095	[a]0.041	0.00023	0.00086	−0.397	0.0104	1.99	1971:*i*–1994:*i*
		(−2.40)	(13.00)	(2.13)	(2.57)	(1.04)	(2.26)	(−3.64)			
FR	U_{-1}(lin)	−0.742	0.848	0.099	[a]0.019	[a]−0.06777	0.00050	0.291	0.0047	1.79	1976:*i*–1995:*ii*
		(−2.74)	(18.14)	(2.76)	(1.35)	(−0.66)	(2.14)	(2.41)			
GE	$G2_{-1}$(lin)	−0.469	0.877	[a]0.047	0.018	[a]−0.07823	0.00053	b	0.0031	1.88	1969:*i*–1994:*iv*
		(−6.26)	(57.14)	(5.51)	(4.65)	(−4.91)	(5.05)				
IT	$G2$(lin)	−0.157	0.941	0.018	0.042	−0.17374	0.00114	b	0.0069	1.69	1971:*i*–1995:*iii*
		(−2.01)	(29.46)	(0.64)	(6.23)	(−5.62)	(4.97)				
NE	none	−0.730	0.714	[a]0.130	0.075	—	0.00091	b	0.0080	1.57	1978:*ii*–1995:*iv*
		(−1.77)	(9.30)	(1.30)	(4.53)		(2.05)				
ST	$G1_{-1}$(lin)	0.002	0.979	c	[a]0.015	[a]−0.13828	0.00016	0.575	0.0031	1.64	1971:*i*–1994:*iv*
		(0.04)	(27.67)		(1.36)	(−4.42)	(0.42)	(5.78)			
UK	none	−0.398	0.856	0.164	0.064	—	−0.00045	b	0.0108	0.99	1966:*i*–1995:*ii*
		(−4.06)	(23.78)	(3.75)	(7.35)		(−1.63)				
FI	U(0.02)	−0.157	0.879	[a]0.090	0.028	0.00057	0.00061	b	0.0076	1.92	1976:*i*–1993:*iii*
		(−1.92)	(12.01)	(1.12)	(2.47)	(3.78)	(1.41)				
AS	G_{-1}(0.02)	0.055	1.001	c	0.020	[a]0.00039	−0.00036	b	0.0105	2.06	1971:i–1995:*iv*
		(1.52)	(79.51)		(1.54)	(3.08)	(−1.56)				
SO	none	−0.127	0.970	c	0.034	—	0.00099	b	0.0176	2.18	1962:*i*–1995*iii*
		(−3.31)	(116.75)		(3.03)		(4.09)				
KO	$G2_{-1}$(0.02)	−0.665	0.696	0.329	0.100	[a]0.00107	−0.00548	−0.256	0.0367	1.87	1964:*i*–1995:*iv*
		(−3.42)	(8.65)	(3.80)	(3.07)	(1.58)	(−3.76)	(−2.36)			

	Best D	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	SE	DW	Sample
Annual										
BE	G2(0.02)	−1.220	0.577	0.219	0.030	0.00056	0.01095	0.0126	1.16	1966–1992
		(−3.79)	(5.28)	(3.61)	(1.09)	(1.43)	(3.33)			
DE	U(0.02)	−2.061	0.634	0.372	0.062	0.00044	−0.00259	0.0079	2.03	1967–1992
		(−9.05)	(13.34)	(10.34)	(2.89)	(1.61)	(−1.13)			
NO	U(lin)	−0.346	0.892	d	0.349	−0.71895	0.01262	0.0256	1.26	1966–1993
		(−1.88)	(11.56)		(3.99)	(−1.15)	(2.07)			
SW	G1(lin)	−1.878	0.619	[a]0.273	0.180	−0.31560	0.01097	0.0176	1.54	1966–1993
		(−2.51)	(5.38)	(2.00)	(6.64)	(−1.75)	(2.23)			
GR	C1(0.02)	−0.165	0.9310	0.046	0.220	0.00103	0.00143	0.0236	1.53	1964–1993
		(−0.90)	(19.32)	(0.76)	(3.98)	(1.51)	(0.26)			
IR	none	−0.462	0.668	0.331	[a]0.093	—	0.00007	0.0258	1.67	1972–1991
		(−1.58)	(4.39)	(1.80)	(0.81)		(0.01)			
SP	G1(0.2)	−0.832	0.739	0.233	[a]0.004	0.00099	−0.00690	0.0151	1.40	1964–1994
		(−6.26)	(19.83)	(11.92)	(0.17)	(2.36)	(−1.75)			
NZ	none	−1.178	0.742	0.252	[a]0.147	—	0.00120	0.0290	1.48	1962–1992
		(−4.59)	(14.27)	(3.21)	(3.03)		(0.21)			
CO	G1(lin)	−3.131	0.527	c	0.098	−0.34885	0.10494	0.0195	2.37	1972–1994
		(−3.33)	(3.86)		(2.41)	(−1.89)	(3.56)			
JO	none	−0.070	0.947	c	0.212	—	0.00486	0.0386	1.82	1971–1995
		(−0.40)	(13.85)		(4.12)		(0.89)			
SY	none	−0.549	0.851	c	0.011	—	0.02017	0.0748	1.38	1965–1994
		(−1.43)	(7.61)		(0.16)		(1.67)			
PA	none	−0.257	0.805	c	0.170	—	0.01077	0.0215	1.57	1976–1993
		(−0.67)	(5.25)		(2.37)		(0.89)			

TABLE 1. *Estimates of the Price Equation,* $p_t = \beta_0 + \beta_1 p_{t-1} + \beta_2(w_t - \lambda_t) + \beta_3 s_t + \beta_4 D_t + \beta_5 t$ *(continued)*

	Best D	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	SE	DW	Sample
PH	none	−0.128	0.924	c	0.213	—	0.00605	0.0542	1.53	1962–1993
		(−0.45)	(12.22)		(4.60)		(0.67)			
TH	G1(lin)	−0.647	0.519	c	0.315	−0.17183	0.02169	0.0251	1.35	1962–1994
		(−6.11)	(7.57)		(7.75)	(−0.82)	(6.33)			

NOTE: t-statistics are in parentheses.
[a]Variable lagged once. [b]ρ taken to be 0. [c]No wage data. [d]Coefficient taken to be 0.
ρ is not estimated for the annual countries.
U = unemployment rate, $G1$ = first output-gap variable, $G2$ = second output-gap variable.
The expression in parentheses following U, $G1$, and $G2$ is 0.02 if the nonlinear form is used and lin if the linear form is used.
$\hat{\beta}_4$ is expected to be negative when the linear form is used and positive when the nonlinear form is used.
CA = Canada, JA = Japan, AU = Austria, FR = France, GE = Germany, IT = Italy, NE = Netherlands, ST = Switzerland, UK = United Kingdom, FI = Finland, AS = Australia, SO = South Africa, KO = Korea, BE = Belgium, DE = Denmark, NO = Norway, SW = Sweden, GR = Greece, IR = Ireland, SP = Spain, NZ = New Zealand, CO = Colombia, JO = Jordan, SY = Syria, PA = Pakistan, PH = Philippines, TH = Thailand.

case where n is 1 and u_t^* is a constant, Equation (5) is simply an equation with $\Delta\pi_t$ on the left-hand side and a constant, u_t, and s_t on the right-hand side. In many cases, however, n is taken to be greater than 1, and/or u_t^* is assumed to be something other than just a constant. Gordon (1997), for example, takes n to be 24 and assumes that u_t^* is time varying. The NAIRU equation in the influential book on European unemployment by Layard, Nickell, and Jackman (1991), Equation (48) on page 379, has n equal to 1 and no variable s_t, but it includes both u_t and u_{t-1} and it has u_t^* a function of unemployment benefits, union power, and some tax rates.

To see how (1) and (2) compare to (5), the wage variable needs to be substituted out of (1). This is done by lagging (1) once, multiplying through by γ_1, subtracting this expression from (1), and then using (2) to substitute out the wage rate. This yields:

$$
\begin{aligned}
p_t = \frac{1}{1-\beta_2\gamma_2}\,[&(\beta_0 + \beta_2\gamma_0 - \beta_0\gamma_1 + \beta_5\gamma_1) + (\beta_1 + \beta_2\gamma_3 + \gamma_1)p_{t-1} \\
&+ \beta_3 s_t - \beta_3\gamma_1 s_{t-1} + (\beta_4 + \beta_2\gamma_4)D_t - \beta_4\gamma_1 D_{t-1} \\
&+ (\beta_5 - \beta_5\gamma_1 + \beta_2\gamma_5)t + (\epsilon_t - \gamma_1\epsilon_{t-1} + \beta_2\mu_t)] \,. \qquad (6)
\end{aligned}
$$

How does (6) compare to (5)? If in (6) D is taken to be u, then both (5) and (6) include u_t. In addition, (6) also includes u_{t-1}, but this is probably a minor difference. For example, as noted above, the NAIRU equation of Layard, Nickell, and Jackman (1991) also includes u_{t-1}. (6) includes s_{t-1}, which (5) does not, but this is perhaps minor also. If u_t^* equals a constant term plus a coefficient times the time trend, then (6) encompasses this specification because there is a constant term and time trend in the equation.

The main difference between (5) and (6) concerns the dynamics. Since $\pi_t = p_t - p_{t-1}$ and n is greater than 0, (5) has more lagged price levels in it than does (6), but with the restriction that each price level is subtracted from the previous price level and the restriction that the δ_i's sum to one. The restriction that each price level is subtracted from the previous price level will be called the "first derivative" restriction, and the restriction that the δ_i's sum to one will be called the "second derivative" restriction.

The dynamics of (5) versus (6) can be tested by adding p_{t-1} and p_{t-2} to (5) and seeing if they are jointly significant. Since (6) implies that these variables belong in the equation, they should be significant according to (6) but not according to (5). Adding one of these variables breaks the second derivative restriction, and adding both breaks both the first and second derivative restrictions. This test was performed in Fair (1998) for the United States and in Fair (1997) for the other countries, and the results strongly

TABLE 2. *Estimates of the Wage Equation,* $w_t - \lambda_t = \gamma_0 + \gamma_1(w_{t-1} - \lambda_{t-1}) + \gamma_2 p_t + \gamma_3 p_{t-1} + \gamma_4 D_t + \gamma_5 t$

	Best D	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_4$	$\hat{\gamma}_5$	$\hat{\rho}$	$\hat{\gamma}_3$	*SE*	*DW*
Quarterly										
CA	none	0.089	0.958	1.097	—	−0.00002	b	−1.050	0.0081	1.64
		(1.61)	(34.06)	(11.90)		(−0.48)				
JA	none	0.431	0.903	1.031	—	−0.00025	b	−0.930	0.0107	1.99
		(2.46)	(23.76)	(9.67)		(−1.70)				
AU	$G2_{-1}$(lin)	2.084	0.680	0.392	[a]−0.15830	0.00039	−0.661	−0.112	0.0157	1.66
		(4.13)	(8.96)	(1.50)	(−2.61)	(2.31)	(−7.58)			
FR	none	0.575	0.924	1.348	—	−0.00022	b	−1.252	0.0092	1.61
		(1.80)	(21.09)	(4.46)		(−1.97)				
GE	U_{-1}(lin)	0.684	0.914	0.922	[a]−0.20253	0.00038	−0.312	−0.843	0.0119	2.16
		(2.69)	(30.15)	(3.27)	(−2.39)	(2.11)	(−3.12)			
IT	U_{-1}(lin)	0.188	0.923	1.244	[a]−0.25124	−0.00026	b	−1.157	0.0139	1.94
		(1.80)	(22.81)	(6.74)	(−1.42)	(−0.91)				
NE	$G2_{-1}$(0.020)	1.638	0.596	−0.025	[a]0.00020	0.00147	0.412	0.269	0.0055	1.96
		(5.76)	(9.06)	(−0.25)	(1.40)	(10.23)	(3.17)			
UK	$G2_{-1}$(0.020)	0.263	0.912	0.790	0.00050	−0.00007	b	−0.697	0.0114	2.22
		(3.03)	(29.51)	(8.83)	(2.44)	(−1.02)				

FI	U_{-1}(lin)	0.149	0.813	0.534	[a]−0.09613	−0.00015	−0.339	−0.361	0.0096	1.96
		(2.13)	(10.06)	(2.43)	(−2.52)	(−1.10)	(−2.37)			
KO	G2(0.020)	0.272	0.952	0.267	0.00197	−0.00024	b	−0.192	0.0283	2.19
		(3.15)	(21.10)	(3.20)	(2.43)	(−0.31)				
Annual										
DE	U(lin)	0.461	0.911	1.353	−0.61265	0.00290		−1.268	0.0139	2.25
		(0.58)	(6.29)	(6.49)	(−3.45)	(2.28)				
SW	G2(0.020)	2.945	0.487	0.396	0.00162	0.00092		0.052	0.0224	2.03
		(3.51)	(3.49)	(2.21)	(3.13)	(0.48)				
GR	G2(lin)	0.261	0.953	0.912	−0.16925	0.00022		−0.867	0.0398	1.53
		(0.78)	(9.96)	(4.20)	(−1.70)	(0.05)				
IR	none	0.192	0.968	0.521	—	−0.00471		−0.489	0.0256	1.64
		(0.64)	(5.32)	(2.52)		(−2.40)				
SP	G2(lin)	0.642	0.845	1.365	−0.14801	0.00281		−1.197	0.0198	2.14
		(3.64)	(16.27)	(8.37)	(−2.41)	(1.46)				

NOTE: t-statistics are in parentheses.
[b]ρ taken to be 0.
See the notes to Table 1.
$\hat{\gamma}_4$ is expected to be negative when the linear form is used and positive when the nonlinear form is used.
The sample periods are the same as those in Table 1.

reject the dynamics implied by (5). p_{t-1} and p_{t-2} are generally highly significant when added to various versions of (5). The NAIRU dynamics are thus strongly rejected and in just the way that (6) suggests they should be.

4. The Experiment

The Setup

The experiment is a decrease in the German short-term interest rate between 1982:*i* and 1990:*iv*. To perform this experiment the interest rate reaction function of the Bundesbank was dropped, and the German short-term interest rate was taken to be exogenous. The reaction functions for all the other countries in the model were retained, which means, for example, that the fall in the German rate directly affects the interest rates of the countries whose reaction functions have the German rate as an explanatory variable. The German interest rate was lowered by 1 percentage point for 1982:*i*–1983:*iv*, by 0.75 percentage points for 1984:*i*–1985:*iv*, by 0.5 percentage points for 1986:*i*–1987:*iv*, and by 0.25 percentage points for 1988:*i*–1990:*iv*.

The first step is to add the estimated (historical) residuals to the model, both for the stochastic equations and for the trade share equations. Doing this and then solving the model using the actual values of all the exogenous variables results in a perfect tracking solution (i.e., the predicted values of the endogenous variables are equal to the actual values). Then the German interest rate is lowered and the model is solved. The difference between the predicted value for each variable for each period from this solution and its actual value is the estimated effect of the monetary-policy change on the variable. Selected results of this experiment are presented in Table 3 for 17 countries, 15 European countries plus the United States and Japan.[8] The rest of this section is a discussion of this table. Each fourth-quarter value is presented in Table 3 for the quarterly countries, while each annual value is presented for the annual countries.

The units in Table 3 require some explanation. The column labeled u^a gives the actual value of the unemployment rate in percentage points, and the column labeled π^a gives the actual value of the inflation rate (percentage change in the GDP price index) in percentage points. These values are provided just for reference purposes. The values in the remaining columns are either absolute or percentage changes *from the base values* (remember that the base values are the actual values). Absolute changes are given for the

[8]The complete model is solved to yield these results, but to save space the results for the other 16 countries are not reported in Table 3.

interest rate, the unemployment rate, the inflation rate, and the current account as a fraction of GDP, while percentage changes are given for the other variables. All the values are in percentage points. The notation for the variables is given at the bottom of Table 3.

Qualitative Discussion

Before looking at the numbers in Table 3, it will be useful to review qualitatively what is likely to happen in the model in response to the decrease in the German interest rate. Consider first the effects of an interest rate decrease in a particular country. A decrease in the short-term rate in a country leads to a decrease in the long-term rate through the term structure equation. A decrease in the short-term rate also leads to a depreciation of the country's currency (assuming that the interest rate decrease is relative to other countries' interest rates). The interest rate decreases lead to an increase in consumption, investment, and imports. The depreciation of the currency leads to an increase in exports. This effect on exports works through the trade-share equations. The dollar price of the country's exports that feeds into the trade-share equations is lower because of the depreciation, and this increases the share of the other countries' total imports imported from the particular country. The effect on aggregate demand in the country from the interest rate decrease is thus positive from the increase in consumption, investment, and exports and negative from the increase in imports. The net effect could thus go either way, but it is almost always positive.

There is also a positive effect on inflation. The depreciation leads to an increase in the price of imports, and this has a positive effect on the domestic price level through the price equation. In addition, if aggregate demand increases, this increases demand pressure, which has a positive effect on the domestic price level.

There are many other effects that follow from these, including effects back on the short-term interest rate itself through the interest rate reaction function, but these are typically second order in nature, especially in the short run. The main effects are as just described.

The decrease in the German interest rate should thus stimulate the German economy, depreciate the mark, and lead to a rise in German prices and wages. How much prices and wages rise depends, among other things, on the size of the coefficient estimates of the demand pressure variables in the price and wage equations and on the functional forms of the demand pressure variables. The size of the wage and price increases also depends on how much the mark depreciates and on the size of the coefficient estimate of the import price variable in the price equation.

For those European countries whose interest rate reaction functions include the German interest rate as an explanatory variable, the fall in the

TABLE 3. *Results of the Experiment*

		Actual		Changes from the Base Values after the German Interest Rate Decrease											
		u^a	π^a	RS	e	Y	u	P	π	W	PM	PX	IM	EX	S
GE	4	9.24	3.72	−1.00	1.47	0.37	−0.08	0.06	0.06	0.06	0.74	0.23	0.63	0.24	−0.30
	8	9.96	2.97	−1.00	2.61	0.87	−0.21	0.26	0.21	0.34	1.20	0.52	1.06	0.63	−0.42
	12	9.92	1.85	−0.75	3.14	1.26	−0.30	0.56	0.31	0.77	1.47	0.83	1.22	0.89	−0.43
	16	9.90	2.47	−0.75	3.67	1.57	−0.35	0.90	0.34	1.24	1.78	1.17	1.42	1.09	−0.43
	20	9.36	2.97	−0.50	3.81	1.79	−0.51	1.24	0.35	1.72	2.02	1.48	1.46	1.23	−0.35
	24	9.51	1.40	−0.50	4.06	1.97	−0.69	1.57	0.33	2.26	2.32	1.80	1.50	1.29	−0.34
	28	9.29	1.90	−0.25	3.96	2.01	−0.73	1.88	0.31	2.80	2.49	2.08	1.43	1.25	−0.36
	32	8.53	2.82	−0.25	3.99	2.05	−0.75	2.14	0.27	3.23	2.77	2.34	1.30	1.12	−0.37
	36	6.44	1.96	−0.25	4.07	2.14	−0.98	2.38	0.23	3.69	3.05	2.58	1.32	1.05	−0.39
FR	4	8.25	8.56	−0.43	1.46	0.14	−0.03	0.02	0.02	0.03	0.70	0.30	0.13	0.32	−0.07
	8	8.50	10.42	−0.53	2.52	0.34	−0.14	0.10	0.09	0.14	1.07	0.53	0.47	0.66	−0.12
	12	10.08	6.25	−0.44	2.90	0.50	−0.26	0.23	0.13	0.30	1.13	0.68	0.76	0.86	−0.13
	16	10.26	5.94	−0.41	3.24	0.63	−0.39	0.38	0.16	0.50	1.31	0.83	1.00	1.04	−0.15
	20	10.52	3.95	−0.29	3.19	0.69	−0.49	0.55	0.17	0.72	1.31	0.95	1.17	1.10	−0.13
	24	10.37	3.29	−0.25	3.27	0.74	−0.56	0.72	0.18	0.94	1.50	1.11	1.21	1.10	−0.15
	28	9.85	2.85	−0.12	3.03	0.73	−0.61	0.89	0.17	1.16	1.55	1.22	1.23	1.05	−0.17
	32	9.15	3.46	−0.09	2.93	0.70	−0.63	1.04	0.16	1.36	1.65	1.36	1.13	0.93	−0.17
	36	8.88	2.59	−0.08	2.91	0.67	−0.63	1.18	0.14	1.54	1.83	1.51	1.06	0.89	−0.18
IT	4	9.98	15.57	0.07	1.47	0.04	0.00	0.09	0.10	0.11	0.77	0.44	0.03	0.27	−0.04
	8	11.01	14.06	0.12	2.62	0.10	−0.02	0.27	0.20	0.34	1.24	0.82	0.10	0.64	0.00
	12	11.32	9.67	0.16	3.14	0.13	−0.03	0.47	0.22	0.60	1.44	1.08	0.16	0.87	0.03
	16	12.03	7.88	0.19	3.65	0.16	−0.04	0.68	0.22	0.87	1.79	1.35	0.20	1.15	0.06

	20	13.01	7.71	0.20	3.76	0.15	−0.04	0.88	0.21	1.12	1.95	1.54	0.23	1.23	0.07
	24	13.63	6.36	0.22	3.96	0.15	−0.04	1.05	0.18	1.34	2.27	1.75	0.23	1.25	0.05
	28	13.02	6.76	0.21	3.82	0.13	−0.04	1.20	0.15	1.51	2.43	1.88	0.21	1.23	0.03
	32	12.66	6.30	0.20	3.78	0.11	−0.06	1.31	0.12	1.65	2.58	2.03	0.19	1.17	0.01
	36	12.27	8.15	0.21	3.80	0.11	−0.06	1.43	0.12	1.79	2.81	2.18	0.16	1.15	−0.01
UK	4	12.32	7.00	−0.01	0.48	0.03	−0.01	−0.06	−0.06	−0.05	−0.27	−0.09	0.04	0.12	0.09
	8	12.58	4.47	−0.02	0.67	0.08	−0.04	−0.22	−0.17	−0.18	−0.79	−0.31	0.14	0.24	0.21
	12	12.86	4.71	0.00	0.55	0.17	−0.09	−0.44	−0.23	−0.36	−1.21	−0.56	0.29	0.33	0.31
	16	12.99	5.79	0.06	0.37	0.29	−0.17	−0.70	−0.28	−0.58	−1.61	−0.85	0.46	0.37	0.27
	20	12.79	2.30	0.18	−0.01	0.39	−0.26	−0.92	−0.22	−0.73	−1.76	−1.10	0.58	0.32	0.18
	24	10.26	5.70	0.31	−0.42	0.45	−0.34	−1.10	−0.19	−0.76	−2.10	−1.33	0.64	0.23	0.18
	28	8.26	7.31	0.41	−0.98	0.43	−0.39	−1.09	0.01	−0.30	−2.38	−1.43	0.61	0.00	0.23
	32	6.83	6.85	0.44	−1.43	0.36	−0.38	−0.91	0.20	0.07	−2.65	−1.39	0.53	−0.24	0.36
	36	7.56	5.28	0.39	−1.75	0.28	−0.32	−0.84	0.07	0.01	−2.82	−1.39	0.42	−0.55	0.35
US	4	10.68	5.25	−0.01	—	0.02	−0.01	−0.04	−0.04	−0.03	−0.41	−0.08	0.09	−0.06	0.02
	8	8.54	3.86	−0.01	—	0.05	−0.02	−0.11	−0.08	−0.09	−0.77	−0.18	0.28	−0.16	0.03
	12	7.28	3.52	0.00	—	0.08	−0.03	−0.19	−0.08	−0.15	−0.98	−0.27	0.50	−0.20	0.02
	16	7.05	3.45	0.02	—	0.09	−0.03	−0.25	−0.07	−0.21	−1.08	−0.34	0.69	−0.21	0.01
	20	6.84	2.52	0.05	—	0.09	−0.03	−0.29	−0.04	−0.25	−0.98	−0.37	0.78	−0.10	−0.01
	24	5.87	3.24	0.06	—	0.09	−0.02	−0.32	−0.02	−0.27	−0.89	−0.39	0.80	−0.04	−0.02
	28	5.35	3.98	0.08	—	0.08	−0.01	−0.31	0.00	−0.28	−0.70	−0.37	0.75	0.00	−0.03
	32	5.37	3.93	0.09	—	0.06	−0.01	−0.29	0.03	−0.27	−0.51	−0.33	0.65	0.02	−0.04
	36	6.11	4.66	0.10	—	0.05	0.01	−0.26	0.03	−0.24	−0.34	−0.29	0.53	0.04	−0.04

TABLE 3. *Results of the Experiment (continued)*

		Actual		Changes from the Base Values after the German Interest Rate Decrease											
		u^a	π^a	RS	e	Y	u	P	π	W	PM	PX	IM	EX	S
JA	4	2.46	0.80	0.00	−0.01	0.00	0.00	−0.01	−0.01	−0.01	−0.15	−0.38	0.01	0.02	−0.04
	8	2.66	2.25	0.00	−0.04	0.01	0.00	−0.03	−0.02	−0.03	−0.34	−0.69	0.03	0.07	−0.06
	12	2.72	3.12	0.01	−0.05	0.01	0.00	−0.05	−0.02	−0.05	−0.47	−0.81	0.05	0.13	−0.06
	16	2.74	1.61	0.02	−0.03	0.02	0.00	−0.06	−0.01	−0.07	−0.57	−0.91	0.07	0.22	−0.05
	20	2.80	1.21	0.02	0.01	0.01	0.00	−0.07	−0.01	−0.08	−0.58	−0.84	0.09	0.22	−0.03
	24	2.71	0.09	0.03	0.09	−0.01	0.00	−0.09	−0.01	−0.09	−0.46	−0.77	0.07	0.19	−0.03
	28	2.43	1.10	0.04	0.18	−0.03	0.01	−0.10	−0.01	−0.10	−0.26	−0.60	0.04	0.16	−0.03
	32	2.25	2.71	0.05	0.26	−0.06	0.02	−0.10	0.00	−0.11	−0.03	−0.43	−0.01	0.13	−0.04
	36	2.10	1.94	0.05	0.34	−0.09	0.02	−0.11	−0.01	−0.11	0.15	−0.30	−0.07	0.11	−0.04
AU	4	4.19	4.74	−0.45	1.47	0.32	−0.07	0.04	0.04	0.07	0.42	0.04	0.27	0.43	−0.10
	8	3.85	3.81	−0.58	2.61	0.83	−0.26	0.22	0.18	0.36	0.77	0.22	0.92	0.91	−0.26
	12	3.76	4.09	−0.50	3.13	1.23	−0.48	0.46	0.25	0.77	1.01	0.46	1.47	1.21	−0.38
	16	3.71	3.36	−0.48	3.64	1.55	−0.70	0.76	0.31	1.20	1.35	0.76	1.88	1.46	−0.47
	20	3.47	4.50	−0.36	3.77	1.75	−0.90	1.03	0.28	1.59	1.65	1.03	2.22	1.67	−0.43
	24	3.58	1.18	−0.33	3.99	1.87	−1.07	1.28	0.25	1.90	1.98	1.28	2.42	1.83	−0.51
	28	3.71	2.10	−0.21	3.88	1.87	−1.20	1.61	0.32	2.22	2.17	1.61	2.34	1.74	−0.46
	32	3.44	2.92	−0.17	3.89	1.74	−1.27	1.97	0.36	2.51	2.47	1.97	2.25	1.59	−0.54
	36	3.34	3.80	−0.16	3.99	1.59	−1.29	2.44	0.49	2.87	2.71	2.45	2.11	1.45	−0.45
NE	4	—	2.24	−0.68	1.36	0.15	—	0.09	0.09	0.02	0.70	0.38	0.57	0.44	−0.28
	8	—	1.28	−0.62	2.40	0.30	—	0.19	0.11	0.08	1.08	0.67	1.19	0.95	−0.40
	12	—	2.13	−0.34	2.82	0.50	—	0.27	0.08	0.15	1.23	0.81	1.47	1.28	−0.37
	16	—	2.34	−0.23	3.18	0.74	—	0.34	0.07	0.20	1.45	0.93	1.61	1.61	−0.31

	20	—	−2.77	0.05	3.14	1.00	—	0.37	0.03	0.25	1.44	0.96	1.42	1.70	−0.17
	24	—	2.09	0.09	3.17	1.09	—	0.41	0.04	0.28	1.56	1.03	1.37	1.83	−0.12
	28	—	0.88	0.30	2.88	1.16	—	0.42	0.02	0.30	1.56	1.01	1.17	1.77	−0.09
	32	—	1.31	0.33	2.68	1.22	—	0.44	0.02	0.34	1.58	1.03	0.97	1.74	−0.04
	36	—	3.05	0.36	2.55	1.31	—	0.47	0.03	0.43	1.61	1.07	0.88	1.85	0.13
ST	4	0.73	6.18	0.02	1.07	0.08	−0.04	0.02	0.02	—	0.15	0.12	0.11	0.28	0.04
	8	1.00	2.12	0.06	1.82	0.18	−0.10	0.08	0.06	—	0.21	0.22	0.27	0.61	0.11
	12	1.14	2.77	0.11	2.09	0.26	−0.14	0.18	0.10	—	0.12	0.32	0.41	0.84	0.20
	16	0.91	3.78	0.18	2.34	0.34	−0.19	0.31	0.14	—	0.16	0.43	0.47	0.98	0.26
	20	0.74	3.51	0.24	2.29	0.39	−0.21	0.48	0.17	—	0.36	0.56	0.42	1.05	0.26
	24	0.67	1.96	0.29	2.34	0.45	−0.22	0.65	0.18	—	0.48	0.72	0.32	1.01	0.29
	28	0.55	3.38	0.34	2.14	0.50	−0.23	0.84	0.20	—	0.60	0.87	0.17	0.93	0.31
	32	0.45	4.23	0.39	2.05	0.56	−0.29	1.05	0.21	—	0.82	1.06	0.00	0.83	0.31
	36	0.75	5.89	0.43	2.03	0.59	−0.38	1.26	0.23	—	0.88	1.25	−0.20	0.72	0.37
FI	4	7.00	8.18	0.00	0.22	0.00	0.00	−0.05	−0.06	−0.03	−0.63	−0.20	0.03	0.00	0.14
	8	7.04	8.78	−0.01	0.57	0.04	−0.01	−0.13	−0.09	−0.09	−1.01	−0.31	0.10	0.06	0.22
	12	6.88	8.45	−0.01	0.85	0.14	−0.06	−0.17	−0.04	−0.12	−1.08	−0.30	0.20	0.21	0.25
	16	6.82	4.36	0.00	1.08	0.23	−0.12	−0.13	0.04	−0.09	−0.93	−0.25	0.30	0.31	0.21
	20	6.72	5.25	0.01	1.24	0.33	−0.17	−0.04	0.09	−0.01	−0.80	−0.11	0.43	0.38	0.18
	24	6.66	4.99	0.03	1.36	0.41	−0.22	0.11	0.16	0.13	−0.53	0.05	0.56	0.49	0.16
	28	5.75	7.50	0.05	1.47	0.46	−0.24	0.37	0.28	0.34	−0.15	0.34	0.54	0.43	0.12
	32	4.51	6.19	0.07	1.71	0.45	−0.31	1.09	0.76	0.87	0.38	0.96	0.52	0.33	0.15
	36	5.36	4.78	0.09	2.16	0.46	−0.35	1.78	0.72	1.49	1.07	1.63	0.48	0.13	0.09

TABLE 3. *Results of the Experiment (continued)*

		Actual		Changes from the Base Values after the German Interest Rate Decrease											
		u^a	π^a	*RS*	*e*	*Y*	*u*	*P*	π	*W*	*PM*	*PX*	*IM*	*EX*	*S*
BE	1	14.46	7.07	−0.42	0.96	0.26	−0.07	0.03	0.03	—	0.36	0.33	−0.03	0.21	0.13
	2	15.72	5.57	−0.58	2.21	0.74	−0.20	0.08	0.05	—	0.83	0.76	−0.09	0.57	0.38
	3	15.71	5.20	−0.53	2.90	1.22	−0.36	0.14	0.06	—	1.13	1.04	−0.13	0.85	0.59
	4	14.79	6.08	−0.50	3.33	1.68	−0.52	0.18	0.04	—	1.33	1.21	−0.13	1.09	0.71
	5	14.13	3.81	−0.38	3.51	2.10	−0.66	0.21	0.04	—	1.60	1.34	−0.13	1.23	0.60
	6	13.84	2.33	−0.33	3.59	2.44	−0.75	0.24	0.03	—	1.76	1.44	−0.11	1.31	0.56
	7	12.79	1.76	−0.20	3.47	2.56	−0.80	0.30	0.06	—	1.88	1.51	−0.10	1.27	0.47
	8	11.69	4.80	−0.15	3.29	2.64	−1.04	0.35	0.06	—	1.98	1.56	−0.08	1.21	0.41
	9	11.08	3.01	−0.13	3.19	2.66	−1.31	0.40	0.05	—	2.08	1.64	−0.08	1.17	0.26
DE	1	12.21	10.56	−0.33	0.98	0.08	−0.03	0.06	0.06	0.10	0.34	0.24	0.01	0.20	0.02
	2	12.70	7.64	−0.50	2.25	0.20	−0.10	0.23	0.18	0.39	0.79	0.61	0.05	0.53	0.09
	3	9.78	5.65	−0.51	3.02	0.31	−0.20	0.57	0.36	0.96	1.17	1.01	0.11	0.81	0.16
	4	8.49	4.33	−0.51	3.63	0.38	−0.28	1.13	0.58	1.85	1.54	1.52	0.19	1.01	0.26
	5	6.68	4.55	−0.42	4.19	0.38	−0.33	2.00	0.90	3.18	2.13	2.25	0.26	1.06	0.26
	6	6.65	4.71	−0.38	4.89	0.35	−0.33	3.18	1.21	4.89	2.89	3.27	0.31	0.98	0.28
	7	7.80	3.39	−0.28	5.66	0.28	−0.30	4.67	1.50	6.98	3.91	4.54	0.32	0.76	0.26
	8	9.49	4.22	−0.22	6.68	0.16	−0.22	6.49	1.81	9.42	5.20	6.13	0.33	0.49	0.24
	9	9.52	2.69	−0.20	8.12	0.01	−0.11	8.67	2.10	12.24	6.86	8.08	0.31	0.13	0.08
NO	1	4.33	10.19	0.01	0.97	0.09	−0.04	0.16	0.17	—	0.36	0.16	0.02	0.24	0.01
	2	5.26	6.10	0.02	2.25	0.24	−0.13	0.45	0.31	—	0.79	0.45	0.05	0.60	0.11
	3	4.74	6.40	0.05	3.01	0.37	−0.22	0.81	0.38	—	1.17	0.81	0.11	0.90	0.22
	4	4.12	5.00	0.09	3.54	0.47	−0.31	1.19	0.39	—	1.49	1.19	0.17	1.12	0.31

	5	3.58	−1.42	0.13	3.85	0.49	−0.37	1.56	0.37	—	1.87	1.56	0.23	1.21	0.22
	6	3.79	7.16	0.17	4.09	0.49	−0.40	1.89	0.35	—	2.15	1.89	0.29	1.25	0.19
	7	4.84	4.41	0.20	4.14	0.47	−0.41	2.20	0.32	—	2.52	2.20	0.31	1.14	0.11
	8	6.61	6.31	0.23	4.15	0.48	−0.42	2.49	0.30	—	2.84	2.49	0.32	1.08	0.12
	9	7.13	4.20	0.24	4.24	0.46	−0.42	2.77	0.28	—	3.18	2.77	0.33	0.99	0.06
SW	1	3.14	8.25	−0.14	0.99	0.04	—	0.09	0.10	0.04	0.43	0.09	0.04	0.20	−0.08
	2	3.45	10.07	−0.22	2.27	0.12	—	0.26	0.19	0.14	0.99	0.26	0.13	0.56	−0.14
	3	3.08	7.58	−0.22	2.99	0.21	—	0.46	0.21	0.30	1.35	0.46	0.24	0.91	−0.11
	4	2.80	6.63	−0.18	3.44	0.28	—	0.67	0.22	0.49	1.65	0.67	0.34	1.21	−0.10
	5	2.97	6.86	−0.10	3.63	0.34	—	0.86	0.20	0.68	1.82	0.86	0.43	1.39	−0.03
	6	2.23	4.76	−0.01	3.72	0.38	—	1.04	0.19	0.88	1.99	1.04	0.48	1.49	−0.02
	7	1.94	6.48	0.09	3.61	0.39	—	1.21	0.17	1.07	2.13	1.21	0.51	1.52	−0.02
	8	1.68	8.03	0.18	3.46	0.39	—	1.35	0.16	1.23	2.27	1.35	0.51	1.50	−0.05
	9	1.98	8.84	0.25	3.41	0.40	—	1.51	0.17	1.37	2.52	1.51	0.51	1.50	−0.07
GR	1	5.78	25.10	—	0.99	0.01	—	0.11	0.14	0.10	0.48	0.49	0.01	0.16	−0.01
	2	7.86	19.12	—	2.29	0.03	—	0.35	0.28	0.32	1.15	1.13	0.03	0.38	−0.04
	3	8.14	20.28	—	3.06	0.06	—	0.63	0.34	0.60	1.61	1.59	0.05	0.52	−0.02
	4	7.81	17.67	—	3.58	0.09	—	0.92	0.34	0.87	1.92	1.92	0.08	0.63	−0.04
	5	7.38	17.52	—	3.85	0.12	—	1.18	0.30	1.13	2.08	2.19	0.10	0.70	−0.02
	6	7.36	14.26	—	4.02	0.14	—	1.41	0.27	1.37	2.28	2.43	0.11	0.63	−0.01
	7	7.67	15.59	—	3.99	0.14	—	1.64	0.26	1.59	2.46	2.60	0.09	0.42	−0.05
	8	7.46	14.49	—	3.91	0.14	—	1.84	0.23	1.81	2.55	2.75	0.11	0.49	−0.05
	9	7.03	20.83	—	3.92	0.15	—	2.04	0.23	2.01	2.81	2.96	0.11	0.47	−0.09

TABLE 3. *Results of the Experiment (continued)*

		Actual		Changes from the Base Values after the German Interest Rate Decrease											
		u^a	π^a	RS	e	Y	u	P	π	W	PM	PX	IM	EX	S
IR	1	12.72	15.18	0.02	0.96	0.08	−0.02	0.00	0.00	0.00	0.51	0.27	0.00	0.25	−0.07
	2	15.24	10.71	0.03	2.21	0.26	−0.09	0.06	0.06	0.03	1.18	0.65	0.08	0.64	−0.10
	3	16.78	6.38	0.03	2.93	0.48	−0.19	0.18	0.13	0.09	1.60	0.94	0.24	1.01	−0.08
	4	18.91	5.19	0.02	3.40	0.67	−0.32	0.32	0.15	0.17	1.89	1.16	0.42	1.32	−0.06
	5	18.53	5.75	0.02	3.65	0.82	−0.46	0.45	0.14	0.24	2.17	1.36	0.56	1.54	−0.06
	6	18.77	2.20	0.04	3.81	0.93	−0.58	0.58	0.13	0.32	2.52	1.54	0.66	1.64	−0.14
	7	17.89	3.39	0.06	3.78	1.00	−0.68	0.71	0.13	0.39	2.77	1.69	0.73	1.68	−0.23
	8	16.90	5.44	0.10	3.70	1.02	−0.76	0.83	0.13	0.46	3.02	1.83	0.74	1.67	−0.35
	9	14.68	−0.78	0.15	3.70	1.00	−0.82	0.94	0.11	0.54	3.33	1.99	0.71	1.60	−0.52
SP	1	19.56	13.93	0.00	0.96	0.06	—	0.01	0.01	0.02	0.54	0.27	−0.14	0.16	0.00
	2	20.85	11.76	−0.01	2.20	0.17	—	0.03	0.03	0.08	1.19	0.61	−0.34	0.40	0.03
	3	23.41	11.62	0.00	2.88	0.28	—	0.08	0.06	0.18	1.45	0.84	−0.45	0.63	0.13
	4	24.58	7.69	0.00	3.30	0.38	—	0.16	0.08	0.33	1.65	1.01	−0.49	0.82	0.18
	5	23.91	11.07	0.01	3.49	0.46	—	0.27	0.12	0.52	1.79	1.15	−0.48	0.95	0.17
	6	22.97	5.85	0.02	3.59	0.52	—	0.43	0.17	0.79	1.91	1.32	−0.45	1.01	0.16
	7	21.81	5.65	0.03	3.51	0.55	—	0.68	0.26	1.16	2.07	1.50	−0.38	1.05	0.13
	8	19.56	7.09	0.04	3.42	0.54	—	1.09	0.43	1.74	2.18	1.77	−0.24	1.05	0.11
	9	18.34	7.31	0.05	3.48	0.48	—	1.72	0.67	2.59	2.40	2.20	−0.05	1.01	0.09

NOTE: [a]Actual values.

Absolute changes for π, RS, S, and u; percentage changes for the rest. All values are in percentage points.

e = exchange rate, EX = real value of exports, IM = real value of imports, P = GDP price index, π = percentage change in P, PM = import price index, PX = export price index, RS = short-term interest rate, S = current account as a percent of nominal GDP, u = unemployment rate, W = wage rate, Y = real GDP.

GE = Germany, FR = France, IT = Italy, UK = United Kingdom, US = United States, JA = Japan, AU = Austria, NE = Netherlands, ST = Switzerland, FI = Finland, BE = Belgium, DE = Denmark, NO = Norway, SW = Sweden, GR = Greece, IR = Ireland, SP = Spain.

German rate will lead to a direct fall in their interest rates. In addition, the depreciation of the mark (relative to the dollar) will lead to a depreciation of the other European countries' currencies (relative to the dollar) because they are fairly closely tied to the mark in the short run through the exchange rate equations.

The Results

Turn now to the results in Table 3. By the end of the nine-year period the German exchange rate relative to the dollar (e) had depreciated 4.07%, the price level (P) was 2.14% higher, the inflation rate (π) was 0.23 percentage points higher, and the unemployment rate (u) was 0.98 percentage points lower—all compared to the base case (the actual values). (An increase in e for a country is a depreciation of the country's currency relative to the dollar.) The current account as a percent of GDP (S) was 0.39 percentage points lower: German imports (IM) rose more than German exports (EX), and German import prices (PM) rose more than German export prices (PX).

The interest rate (RS) for France fell because French monetary policy is affected by German monetary policy. (The German interest rate is an explanatory variable in the French interest rate reaction function.) By the end of the period the French exchange rate had depreciated 2.91%, the price level was 1.18% higher, the inflation rate was 0.14 percentage points higher, and the unemployment rate was 0.63 percentage points lower. Note that although both the mark and the French franc depreciated relative to the dollar (4.07% and 2.91%, respectively), the franc depreciated less and thus appreciated relative to the mark. This is because of the smaller rise in the domestic price level in France than in Germany.

The Italian lira is closely tied to the mark in the model, and the lira depreciated almost as much as the mark. This led to a rise in the Italian price level, which led the Italian monetary authorities to raise the interest rate. This offset much of the stimulus from the depreciation. By the end of the period the price level was 1.43% higher, the inflation rate 0.12 percentage points higher, and the unemployment rate 0.06 percentage points lower.

The U.K. results are a little more complicated to explain. The pound initially depreciated relative to the dollar, but by less than did the mark. The pound thus appreciated relative to the mark (and other European currencies), and this appreciation was large enough to lead to a decrease in the overall U.K. import price index. This in turn had a negative effect on the U.K. domestic price level. The U.K. was thus in the envious position of having a lower price level and a lower unemployment rate. U.K. export prices (PX) fell less than did U.K. import prices (PM), and this is the main reason for the increase in the U.K. current account (S). The increase in the U.K. current account is an increase in net U.K. foreign security and reserve hold-

TABLE 4. *Changes from the Base Values after 36 Quarters*

	Price Level	Inflation Rate	Unempl. Rate	Output
GE	2.38	0.23	−0.98	2.14
FR	1.18	0.14	−0.63	0.67
IT	1.43	0.12	−0.06	0.11
UK	−0.84	0.07	−0.32	0.28

ings, and this increase has a positive effect on consumption. This positive effect on consumption is the main reason for the increase in U.K. output. By the end of the period the U.K. price level is 0.84% lower, the inflation rate is 0.07 percentage points higher, and the unemployment rate is 0.32 percentage points lower.

The main effect on the U.S. was a fall in the price of imports, caused by the appreciation of the dollar relative to the European currencies. This led to a slight fall in the U.S. domestic price level and to an increase in U.S. imports. The net effect on U.S. output was small. Similarly, the Japanese price of imports fell, and there was a slight fall in the Japanese domestic price level.

The results for the remaining 11 European countries in Table 3 should be fairly self explanatory. The currencies depreciated relative to the dollar because they are closely tied to the mark, and these depreciations stimulated the economies. In addition, the interest rate in a number of countries fell in response to the fall in the German interest rate, and this was stimulative. Therefore, both prices and output rose in the countries. Denmark is an outlier in the size of its exchange rate response, which suggests that the Denmark exchange rate equation may not be well specified.

5. Conclusion

Table 4 helps bring together some of the main results in Table 3. Are these estimated price level and inflation costs worth incurring for the resulting gains in output and decreases in unemployment? The answer to this depends, of course, on one's welfare function, but it seems likely, given the fairly small estimated costs, that many welfare functions would call for accepting the costs. In other words, many people are likely to agree that the Bundesbank should have been more expansionary in the 1980s based on these estimated price level and inflation costs. Remember that these results are not governed by the NAIRU dynamics. It is not the case that an experiment like this will result in accelerating price levels, so there are no horrible events lurking beyond the 36-quarter horizon of the present experiment.

Whether one accepts this conclusion depends, of course, on whether one thinks the price and wage equations underlying it are any good. The tests in Fair (1997, 1998) strongly support the equations' dynamics and reject the NAIRU dynamics, and so I would argue that the current results should be taken seriously.

The results of estimating the price and wage equations do not, however, pin down the point at which the relationship between the price level and unemployment becomes highly nonlinear. Although the best fitting functional forms of the demand pressure variables were used for the results in Table 3, other functional forms usually gave similar fits. As mentioned in the introduction, this is not a problem for the present paper because the experiment is over a period in which unemployment was generally quite high, but it does mean that the MC model should not be pushed into values of the unemployment rate much lower than have been observed historically.

The main message for policy makers from the estimates of the price and wage equations and the tests of the NAIRU dynamics is that policy makers should not think there is some value of the unemployment rate below which the price level accelerates and above which it decelerates. They should think instead that the price level is a negative function of the unemployment rate (or other measure of demand slack), where at some point the function begins to become highly nonlinear. How bold a policy maker is in pushing the unemployment rate into uncharted waters will depend on how fast he or she thinks the nonlinearity becomes severe. The results in Table 3 suggest that more pushing could have been done in Europe in the 1980s with fairly modest price level costs.

Received: June 1997
Final version: January 1998

References

Alogoskoufis, George, Charles Bean, Giuseppe Bertola, Daniel Cohen, Juan Dolado, and Gilles Saint-Paul. *Unemployment: Choices for Europe*. London: Centre for Economic Policy Research, 1995.

Fair, Ray C. *A Model of Macroeconomic Activity. Volume I: The Theoretical Model*. Cambridge, MA: Ballinger Publishing Co., 1974.

———. *Specification, Estimation, and Analysis of Macroeconometric Models*. Cambridge, MA: Harvard University Press, 1984.

———. *Testing Macroeconometric Models*. Cambridge, MA: Harvard University Press, 1994.

———. "Testing the NAIRU Model for 27 Countries." April 1997.

———. "Testing the NAIRU Model for the United States." June 1998.

Gordon, Robert J. "The Time-Varying NAIRU and its Implications for Economic Policy." *Journal of Economic Perspectives* 11 (1997): 11–32.

Layard, Richard, Stephen Nickell, and Richard Jackman. *Unemployment*. Oxford: Oxford University Press, 1991.