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Global Factors, Unemployment Adjustment and the Natural Rate

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Abstract:

OECD unemployment rates show long swings which dominate shorter business cycle components and these long swings show a range of common patterns. Using a panel of 21 OECD countries 1960-2002, we estimate the common factor that drives unemployment by the first principal component. This factor has a natural interpretation as a measure of global expected returns, which is given added plausibility by the fact that it is almost identical to the common factor driving investment shares. We estimate a model of unemployment adjustment, which allows for the influence both of the global factor and of labour market institutions and we examine whether the global factor can act as a proxy for the natural rate in a Phillips Curve. In 15 out of the 21 countries one cannot reject that the same natural rate, as a function of the global factor, appears in both the unemployment and inflation equations. In explaining both unemployment and inflation, the global factor is highly significant, suggesting that models which ignore the global dimension are likely to be deficient.

JEL: J1, E2

Keywords: Unemployment dynamics; labour market institutions investment; principal components; global factors

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1 Introduction

OECD unemployment rates show long swings, which dominate shorter business cycle movements. Over periods like 1960-2003, unemployment rates in the 21 OECD countries we analyse appear to be very persistent series showing stochastic trends. They also show both a range of common patterns and a range of national differences. According to one view, broad movements in unemployment across the OECD can be explained by shifts in labour market institutions, e.g. Nickel et al. (2005), hereafter NNO. However, this view has been subject to a challenge, which attributes changes in unemployment to shocks in global capital or product markets rather than labour market institutions, e.g. Phelps (1994), Oswald (1997), Carruth et al. (1998), Pissarides (2001) or Baker et al. (2004). An intermediate position is that shocks drive unemployment, but the speed of adjustment of unemployment to the shocks, as well as the magnitude of the response, is determined by labour market institutions, e.g. Blanchard and Wolfers (2000), Layard et al. (1991) and chapter 17 of Phelps (1994). Evaluating these approaches empirically is problematic because both labour market institutions and global shocks are difficult to measure. We will use standard measures of labour market institutions and measure the global factor by the common component of OECD unemployment. We then investigate the role of domestic labour market institutions in transmitting this global factor into national unemployment rates and whether the global[1] factor can act as a proxy for the natural rate in a Phillips curve.

Rather than trying to devise measures of global influences from the very large number of candidate measures, we look at the common component of OECD unemployment, measured by their first principal component[2]. This is not a cyclical measure because, like OECD unemployment rates, it is a very persistent series. The shocks can be represented by innovations to this series. Based on the empirical evidence, we also provide a possible interpretation of this factor. The demand for labour (and capital) will depend on the expected return on production, which will have a global and a national component. A large number of variables will influence global expected returns and the confidence with which these expectations are held. These include global competition which affects the elasticity of demand and labour costs; other input costs including oil, commodity prices and real interest rates which affect the cost of capital; technology which influences total factor productivity; and 'sunspot' variables which drive 'animal spirits'. A number of these variables have been suggested as possible explanations for persistently high unemployment.

One could of course try to measure expected returns or their determinants directly, but this is likely to be difficult for the same sort of reasons that measuring expected returns in finance is difficult (Pastor et al. (2006)). Therefore, it may be easier to measure them indirectly by their consequences, the common component in global labour (or capital) demand. The interpretation of the common factor in unemployment as reflecting expected returns is given added plausibility since the common factor in

[1] In this paper, when we say global we mean our OECD sample. This is a reasonable approximation for most of our sample period, but becomes less good towards the end with the growth of China and India.

[2] This approach follows the factor augmented VAR literature e.g. Bernanke et al. (2005), Stock and Watson (2005), but unlike them we do not transform the variables to make them stationary before extracting the factors, since our interest is in the persistent component. Such cointegrating factor augmented error correction models are discussed in Banerjee and Marcellino (2008).

unemployment is almost identical to the common factor in OECD shares of investment. In Section 2 we discuss the measurement of the global factor. In Section 3 we provide a model of the adjustment process by which national unemployment responds to the global factor and examine how labour market institutions may influence the parameters of that process. In Section 4 we provide estimates of the unemployment adjustment model. In Section 5 we provide estimates of a Phillips Curve augmented by global factors. Section 6 concludes.

2 Global Factors

We use OECD data for twenty-one countries[3] and forty-three years (1960-2002) on the unemployment rate u_{it} in country i in year t, $i = 1,2,...,N; t = 1,2,...,T$, which we can stack in the $T \times N$, (43×21) matrix U. Standard tests do not reject a unit root in all 21 series. We assume that u_{it} has a factor structure

$$u_{it} = \lambda_i f_t + e_{it} \tag{1}$$

Similarly we have data on the investment rate, Gross Domestic Fixed Capital Formation as a share of GDP, g_{it}, stacked as G. We standardise the data and calculate the underlying global factors as the principal components (PCs) of the correlation matrices of U and G. These are the orthogonal linear combinations of the data that explain the maximal variances of the data[4]. If the idiosyncratic errors, e_{it} above are I(0) the PC estimators for f_t are consistently estimated (large *N*) independently of whether all the factors are I(0) or whether some or all of the factors are I(1) (Bai and Ng (2004)). We will assume that the errors are I(0) and that the long-memory in investment and unemployment comes from the persistent global factors. We test for the cointegration of unemployment and the global factor below.

The eigenvalues and proportion of variance explained by the first four PCs are given in Table 1. The first PC explains almost 70% of the variation in unemployment and almost 60% of the variation in investment; factors common to all countries clearly explain the bulk of the variation in both variables[5]. The first PC of unemployment is close to the mean with most countries having roughly equal weights, between 0.18 and 0.26, the main exception being the US, which has a low weight of 0.08, but a high weight in the second PC of unemployment. The eigenvectors (loadings) for the first four PCs are given in Appendix A1.

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[3] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, UK and US.

[4] For forecasting, it may be more useful to estimate dynamic factors that take the principal components of the spectral density matrix. However, static factors are commonly used in the FAVAR literature. Stock and Watson (2005) discuss the relation between dynamic and static factor analysis.

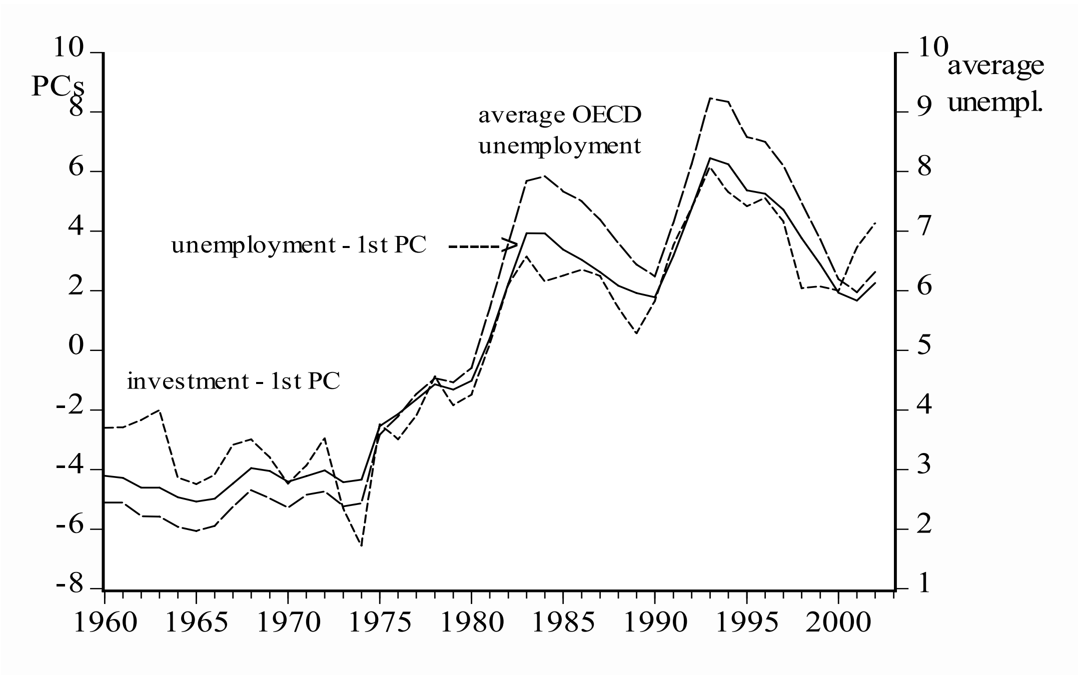
[5] The fact that a global factor is important for investment is also indicated by the Feldstein-Horioka literature, where there is substantial cross-section dependence in the residuals of panel regressions of investment shares on savings shares, e.g. Coakley et al. (2004).

Table 1: Principal Components for Unemployment and Investment

	Unemployment			Investment		
Shocks	Eigen-values	% of var. explained	Cum. % explained	Eigen-values	% of var. explained	Cum. % explained
First PC	14.16	69%	69%	11.85	58%	58%
Second PC	3.15	15%	84%	2.44	12%	70%
Third PC	0.98	5%	89%	1.59	8%	78%
Fourth PC	0.74	4%	93%	1.00	5%	83%

Notice that we have calculated the factors for unemployment and investment independently and not imposed a shared factor structure. However, by plotting the unemployment and investment PCs together we can judge whether they share a common factor or whether there are only variable specific factors. The first PCs for unemployment and investment are shown in Figure 1 below, in addition to average OECD unemployment. Note that we draw the negative of the PC for unemployment in order to create a more visible fit with the investment PCs.

Figure 1: The First Principal Components and Average OECD Unemployment



The first PCs for investment and unemployment are almost identical, $R^2 = 0.92$. This relationship is not spurious, they cointegrate[6] and the (1,-1) restriction on the cointegrating vector is accepted at the 5% level, t=1.53. The disequilibrium term feeds back significantly on investment but not on unemployment. Since employment can be adjusted faster than capital stock this is not surprising. The contemporaneous residual correlation is very high, 0.81, so they both seem to be responding to the same shocks, which we interpret as innovations to expected returns. As can be seen from the graph the fit is less good in the 1960s, which is consistent with growing globalisation over this period, particularly after the end of the fixed exchange rate Bretton Woods system.

The first PC reflects some of the more important macroeconomic events of the past forty years: the oil shocks, the recessions of the mid-seventies, early eighties and early nineties and the gradual but only partial recovery in the second half of the eighties. This component describes the shocks causing the persistent slump that occurred in many countries in the seventies, eighties and nineties.[7]

As noted above, the expected return to production may depend on a large number of factors, many of which are difficult to measure. But in a globalised world the broad movements of the expected rate of return are likely to be quite similar across the advanced industrial countries, and reflected in their investment and employment decisions. Whereas investment and unemployment in any one country will be noisy measures of this, the common component across countries may be a better measure. While we do not observe expected returns, we do observe a variable related to it. Figure 2 plots a discount factor calculated from the world real rate of interest: $d = 1/(1+r)$, where r is the average (long) real rate of interest for the G7 countries.[8]

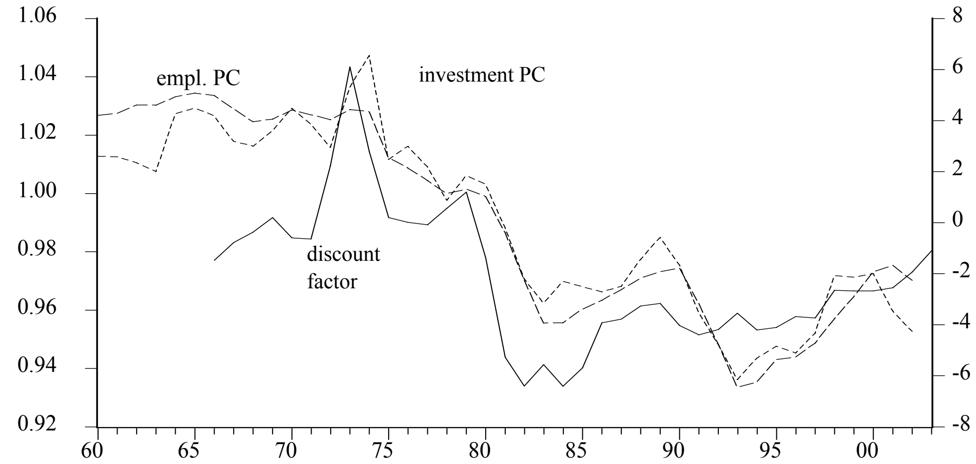
A clear relationship is present between the two PCs, on the one hand, and the discount factor, on the other hand. This suggests that the long swings of employment may trace their roots to factors affecting expected returns and the same factors drive investment. This pattern is consistent with a variety of theoretical models. For instance, Xiao (2004) derives an International Real Business Cycle (IRBC) model with increasing returns in the production technology that generate sunspots. These sunspots are interpreted as self-fulfilling demand shocks, like animal spirits, and generate positive international correlations of output, employment and investment, unlike most IRBC models. Similarly Harrison and Weder (2006) find that a sunspot model driven by a measure of expectations can explain the entire Great Depression era in the US. Increasing returns are not necessary, Hashimzade and Ortigueira (2005) find that a neoclassical model with labour market frictions displays expectations driven business cycles where the indeterminacy of equilibrium stems from job search externalities. In

[6] The AIC chooses no intercept, no trend in the relationship and with this the trace test for the rejection of no cointegrating vectors has a p value of 0.0173, while the less reliable max eigenvalue test has a p value of 0.0519.

[7] There is a growing literature that seeks to explore the similarities and linkages between macroeconomic cycles across countries. For instance, Kose et al (2003) also find a common world cycle. But again they are examining the stationary component, rather than the persistent component that we focus on.

[8] The world real rate of interest is calculated as the weighted average of the real rate of interest in the G7 countries; the real rates being the difference between the long nominal rates and annual inflation and the weights being the Heston-Summers relative GDP for each country.

Figure 2: The First PCs and the World Discount Factor



the unemployment literature, we have models where equilibrium unemployment depends on the real rate of interest. In Pissarides (2001) firms respond to higher real interest rates by opening up fewer vacancies, resulting in an elevation of equilibrium unemployment. In Phelps (1994) higher interest rates make firms train fewer recruits, charge higher markups of price over marginal cost and reduce the production of labour-intensive capital goods. This causes the natural rate of unemployment to increase.

Changes in labour supply may provide an alternative explanation. However, the composition of the labour force is slow moving, both in terms of the share of the working-age population as well as in terms of the educational composition. Francesconi et al. (2000) demonstrate that changes in the educational composition of the labour force affect both the level and the behaviour over time of the aggregate national unemployment series. Interestingly, they find that that the US unemployment series have the "European" shape – experience upward mean shifts in the mid 1970s and the early 1980s – once changes in the educational composition are accounted for because the within-education group series all have that appearance. Hence, taking labour supply into account will make the first unemployment PC explain more and render the second PC less important. Shimer (1998) finds that changes in the age composition of the US labour force explain the rise in unemployment during the fifties and the sixties and the decline in the eighties and the nineties. He finds that the entry of the baby boom led to an increase in unemployment while the aging of this generation has the effect of lowering the aggregate US unemployment rate. However, these changes are too gradual to fit the pattern of the first unemployment PC.

3 The Adjustment Process

Firms will determine their profit-maximising levels of employment and investment conditional on their expectations of the rate of return on production. Corresponding to the profit maximising level of employment will be an optimal or equilibrium rate of unemployment, u_{it}^{*}. This profit maximising level will be shifted by factors shifting the expected returns; the more profitable expected production, the lower optimal unemployment. Suppose that we take the interpretation of the first PC of OECD unemployment, f_t , as a measure of global expected returns then the optimal level of unemployment is given by

$$u_{it}^{*} = a + bf_t. \tag{2}$$

Below we will allow the parameters to vary with countries and time, but we abstract from that for the moment. There will be a similar equation for the share of investment.

Following the approach in Nickell (1985) let us assume that firms have an infinite horizon and minimise the present value of future loss

$$L_{it} = E_t \sum_{j=0}^{\infty} \delta^j \left[\frac{1}{2}(u_{i,t+j} - u^{*}_{i,t+j})^2 + \frac{\theta}{2} \Delta u_{i,t+j}{}^2 \right] \tag{3}$$

where δ is the discount factor and θ measures costs of adjustment. The loss stems from employment differing from the profit-maximising level and the cost of adjusting employment, measured by the parameter θ. The Euler equation takes the form

$$\delta u_{i,t+1} - (1 + \delta + \theta^{-1}) u_{it} + u_{i,t-1} = -u_{it}^{*} / \theta \tag{4}$$

Solving the Euler equation requires finding the two roots $\mu_1 < 1 < \mu_2$ that solve

$$\delta\mu^2 - (1 + \delta + \theta^{-1})\mu + 1 = 0\,. \tag{5}$$

Calling the stable root μ , the optimal policy is then given by

$$\Delta u_{it} = (1 - \mu)(\hat{u}_{it} - u_{i,t-1}) \tag{6}$$

where

$$\hat{u}_{it} = (1 - \delta\mu) E_t \left[\sum_{j=0}^{\infty} (\delta\mu)^j \, u_{i,t+j}^{*} \right], \tag{7}$$

the present discounted value of all expected future targets. To make this operational requires a model for optimal unemployment, u_{it}^{*}, which will be driven by f_t. Suppose the process is

$$\Delta u_{it}^{*} = \rho \Delta u_{i,t-1}^{*} + \varepsilon_{it} \tag{8}$$

The data for f_t, which determines u_{it}^{*} do not reject a unit root; the estimate of $\rho = 0.58$ and the constant is not significantly different from zero. This can then be used to forecast the future targets and, with this specification the unemployment adjustment equation becomes

$$\Delta u_{it} = c \Delta u_{it}^{*} + d(u_{i,t-1}^{*} - u_{i,t-1}) \tag{9}$$

where $c = (1 - \mu)/(1 - \rho\delta\mu)$ and $d = (1 - \mu)$.

Substituting for u_{it}^{*} we get

$$\Delta u_{it} = cb\Delta f_t + d(a + bf_{t-1} - u_{i,t-1}) \tag{10}$$

This is a standard error correction equation, in which changes in unemployment are driven by shocks, changes in the global factor, f_t, and by the adjustment of u_{it} to its steady state value determined by the same variable.[9]

The parameters of the expectations process for Δf_t seem structurally stable by Cusum and CusumSquared tests, but one would not expect the economic parameters (the discount rate, δ, and the cost of adjustment, θ, which determine μ) to be constant across countries and time. In particular, it is possible that institutions would influence both the discount rate and the cost of adjusting employment. Suppose that we have a $k \times 1$ vector of variables x_{it}, which measure labour market institutions with the first element being unity, then we can make the economic parameters functions of x_{it}:

$$\Delta u_{it} = [c' x_{it}]\Delta f_t + [d' x_{it}]([a' x_{it}] + [b' x_{it}] f_{t-1} - u_{i,t-1}) \tag{11}$$

where a, b, c, d are now $k \times 1$ parameter vectors[10]. There are four routes that the institutional variables can influence unemployment: (a) through the domestic component of the equilibrium level of unemployment; (b) through the long-run effect of the global factor on the equilibrium level of unemployment; (c) through the impact of shocks to the global factor on the change in unemployment and (d) the speed of adjustment to equilibrium.

To allow for higher order adjustment processes we add the lagged change of the global factor and the lagged change in unemployment. To allow for national shocks and perhaps monetary policy, we add lagged inflation.[11] We treat the coefficients of these last three variables as independent of institutions to save degrees of freedom. Adding the additional variables and an error term gives:

$$\begin{aligned}\Delta u_{it} = [c' x_{it}]\Delta f_t + [d' x_{it}]([a' x_{it}] + [b' x_{it}] f_{t-1} - u_{i,t-1}) + e_1 \Delta f_{t-1} \\ + e_2 \Delta u_{i,t-1} + e_3 \Delta p_{i,t-1} + \varepsilon_{it}\end{aligned}. \tag{12}$$

There are a large number of possible institutional variables that could be included as elements of x_{it}. We use five that have appeared regularly in the literature, taken from the Labour Market Institutions database of Nickel and Nunziata, extrapolating the final values to the rest of our sample. They are generally measured over multi year periods and available for 19 of our 21 countries, not Greece and Iceland. These are; the coordination of bargaining (*coord*) with a range {1,3} increasing in the degree of coordination on employers as well as unions side; benefit replacement rates (*rr*); the duration of benefits (*dur*); employment protection (*emp*) with range {0,2} increasing with the strictness of employment protection; and, finally union density (*den*).

There is the obvious problem that institutions are likely to be endogenous, responding both to global factors and national unemployment. To investigate this we

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[9] Higher order autoregressive processes for Δu^*_{it} add further lags of it in the equation. In the case of Δf_t the second lag is just significant. We allow for this in estimation. Pesaran (1991) suggests an alternative interpretation of higher order in terms of further adjustment costs.

[10] Strictly the coefficient on Δf_t should be $[c' x_{it}][b' x_{it}]$, but we use this simpler formulation.

[11] The first difference of the inflation rate turned out to have a statistically insignificant coefficient throughout.

ran a random effects[12] panel estimator for each institutional measure on its lagged value, the lagged global factor and lagged unemployment. The global factor was just significant for *emp* (t=-2.071) and significant for *den* (t=-3.008). Thus there may be some effect of the global factor on those two variables, but since national unemployment is never significant, endogeneity is unlikely to be a problem.

4 Empirical Results

To assess the explanatory power of our global factor, we first estimated a model in which the parameters are constant over time but differ for each country:

$$\Delta u_{it} = c_i \Delta f_t + d_i (a_i + b_i f_{t-1} - u_{i,t-1}) + e_{1i} \Delta f_{t-1} + e_{2i} \Delta u_{i,t-1} + e_{3i} \Delta p_{it-1} + \varepsilon_{it} . \qquad (13)$$

The estimates for the individual countries are given in Appendix A2. For large N and T, Pesaran (2006) shows that, under relatively weak assumptions, such regressions using weighted averages, like f_t, as additional regressors give consistent estimates of the coefficients and reduce cross-section dependence in the residuals[13].

Using standard critical values Δf_t is significant in 17 countries; f_{t-1} is significant in 14; and Δf_{t-1} in 6. Only in Japan is no measure of the global factor significant. Lagged unemployment is significant in 16, the lagged change in 11 and lagged inflation in 6. The R^2 for changes in unemployment is below 0.5 in Iceland and Japan; and above 0.7 in 10 countries. Under the null of no long-run relationship the test statistics are non-standard. Pesaran Shin and Smith (2001) provide a bounds test for a long-run relationship, which is appropriate whether the variables are I(0) or I(1). Assuming the variables are I(1) we can reject the null hypothesis of no long-run relationship between unemployment and the global factor in 12 of the 21 countries at the 5% level[14]. Another four are uncertain, lying between the 10% I(0) bound and the 5% I(1) band. The tests would not reject no long-run relation in Denmark, Germany, Ireland, New Zealand and Sweden. On balance this suggests that the national idiosyncratic factors are I(0) in most countries and the stochastic trend in unemployment comes from the global factor. Panel cointegration tests would not be informative here, since the null hypothesis of such tests, no cointegration in any country, is not very interesting because there is clearly cointegration in most countries.

The equation was estimated by the Swamy RCM method (see Appendix A3), which takes precision weighted averages of the individual country coefficients, with non-parametric standard errors, and by fixed effects, which imposes homogeneity of slopes across countries. The results are given in Table 2.

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[12] Because some institutions in some countries do not change a fixed effect estimator cannot be used.

[13] There is an issue as to whether it is better to use a priori weights (e.g. the mean) or estimated weights (e.g. the PC). Here it does not make much difference since the PC is very close to the mean and they both give very similar results. There is also an issue as to how one would endogenise the global factor. Both issues are discussed in Pesaran and Smith (2006).

Table 2: Unemployment and the Global Unemployment Factor

Dependent variable Δu_{it}, $N = 21$, $T = 1963-2002$				
	RCM		FE	
	coefficient	t-ratio	Coefficient	t-ratio
Δf_t	0.59	8.8	0.62	13.3
f_{t-1}	0.12	4.0	0.07	7.0
Δf_{t-1}	-0.23	-6.0	-0.27	-5.8
u_{it-1}	-0.18	-5.8	-0.10	-9.0
Δu_{it-1}	0.38	8.0	0.44	9.1
Δp_{it-1}	0.82	2.7	0.69	1.6

For the fixed effect, $R^2 = 0.48$, $SER = 0.65$. The maximised log-likelihood for the fixed effect estimator -818 compared to a total MLL of –484 for the heterogeneous estimator given in A2. Homogeneity of the parameters is massively rejected, but if we are primarily interested in average effects, which is what most of the theory is concerned with, this may not matter. The Fixed Effect Estimates are very similar to the Swamy estimates, except that the speed of adjustment is lower, which is what one should expect from the heterogeneity bias discussed in Pesaran and Smith (1995). The long-run effect of the global factor is almost identical, 0.68 versus 0.7. Imposing homogeneity does not seem to influence the estimates of the average effect.

We examined various alternative measures of the global factor. If one uses a two way fixed effect estimator, which allows for an unrestricted factor influence by introducing 39 completely free time dummies the MLL is -815 as compared to -818 using the f_t variables in Table 2. This is a tiny improvement for a lot of extra estimated parameters. Using mean unemployment instead of the global factor gets the same fit as the two way fixed effect as one would expect. Because the first principal components of unemployment and investment and mean OECD unemployment are so highly correlated, it makes very little difference to the estimates which is used. The first principal component of unemployment seems to fit slightly better than the first principal component of investment using the fixed effect estimator so this is our preferred measure. We also added the second principal component of unemployment to the first and this is not significant. The full results are given in Appendix A4.

We examined the structural stability of the relationship by estimating the model over the period 1963-1982 and 1983-2002. The RCM estimates are given in Table 3. The estimates for the two periods are very similar, the biggest difference being that the coefficient on lagged unemployment is larger in the first period. The long run effect of the global factor is 0.61 in the first period and 0.87 in the second, perhaps reflecting increased globalisation. It is probably safer not to put too much weight on this, since a trend interacted with the global factor was not significant. It is also noticeable that the coefficient of lagged unemployment is lower in both sub-periods than in the whole period. This may reflect the downward small T bias that results from reducing T from 40 to 20. The fixed effect estimates for the two periods showed similar features. With

[14] F statistics are given in Table A2, the critical values assuming restricted intercept and no trend for one independent variable are 5% 3.62-4.16 and 10% 3.02-3.51, where the first assumes the variables are I(0) and the second I(1).

the fixed effect estimates one can test for coefficient equality in the two periods. Since the variances were very similar in the two periods, Chow's first test is appropriate. Each fixed effect regression estimates 6 slope parameters and 21 intercepts, so the distribution is F(27,786). The test statistic is 2.6 which would certainly reject the null of parameter constancy, given the large sample. But while significant the differences are not large.

Table 3: Structural Stability

Dependent variable Δu_{it}, $N = 21$, RCM estimates				
	$T = 1963-1982$		$T = 1983-2002$	
	Coefficient	t-ratio	Coefficient	t-ratio
Δf_t	0.50	6.6	0.61	5.1
f_{t-1}	0.23	2.9	0.20	3.3
Δf_{t-1}	-0.18	-1.8	-0.23	2.7
u_{it-1}	-0.38	-4.0	-0.23	-3.6
Δu_{it-1}	0.32	3.0	0.36	4.9
Δp_{it-1}	0.42	2.6	0.46	1.2

We now allow the variation in parameters between countries and over time to be determined by the institutional variables. To allow for country specific intercepts, we used deviations from the means, $\tilde{u}_{it} = u_{it} - \bar{u}_i$ and estimated by non-linear least squares the full model for the 19 countries for which we had institutional data, dropping Greece and Iceland. The fixed effects estimates for the 19-country sample were almost identical to those from the 21-country sample with a MLL of –746.9. The full model has 26 slope parameters:

$$\Delta\tilde{u}_{it} = [c'x_{it}]\Delta f_t + [d'x_{it}]([a'x_{it}] + [b'x_{it}]f_{t-1} - \tilde{u}_{i,t-1}) + e_1\Delta f_{t-1} + e_2\Delta\tilde{u}_{i,t-1} + e_3\Delta p_{i,t-1} + \varepsilon_{it}{}' \quad (14)$$

This had a MLL of –714.3 and the results are given in Appendix A5. Dropping the least significant coefficient (except constants) and re-estimating sequentially led to the specification shown in Table 4, where the t ratios are calculated using robust standard errors.

The R^2 in levels is 0.96, close to that obtained by NNO of 0.98, with country specific trends and time effects and many more variables. The fit for the individual countries was generally good, with the R^2 for the level of unemployment over 0.95 in 13 of the 19 countries. It was below 0.9 only for the US, 0.3, and Portugal 0.88. The US appears to be different, this R^2 is a lot lower than obtained with the country specific equation shown in A2: allowing for institutions but otherwise imposing common parameters leads to a severe deterioration in the explanation for the US. Over all countries, the institutional variables have no effect on the domestic component of equilibrium unemployment. Increased coordination reduces the speed of adjustment from 0.19, when coordination takes its lowest value 1, to 0.07 when it takes its highest value 3. NNO get a speed of adjustment of 0.15. Increased employment protection reduces the short run effect of changes in the global factor on changes in unemployment

Table 4: Institutions and Unemployment Adjustment,
Allowing for Country Specific Means

Dependent variable Δu_{it} , $N = 19, T = 1963 - 2002$

	coefficient	t-ratio
a_0	-0.92	3.3
f_{t-1}	0.25	2.4
$emp * f_{t-1}$	0.35	4.3
$dur * f_{t-1}$	0.26	2.2
Δf_t	0.65	5.4
$emp * \Delta f$	-0.24	2.9
$rr * \Delta f_t$	0.58	3.1
$\tilde{u}_{it-1}$	0.25	4.8
$coord * \tilde{u}_{it-1}$	-0.06	2.6
Δf_{t-1}	-0.29	5.9
$\Delta \tilde{u}_{it-1}$	0.41	7.6
Δp_{it-1}	2.20	3.3

$R^2 = 0.52, \; SER = 0.63, \; MLL = -727$.

but increases the long run effect of the global factor on equilibrium unemployment. A higher replacement ratio increases the short run effect of changes in the global factor. A higher duration of benefits increases the long-run effect on equilibrium unemployment. Higher lagged inflation raises equilibrium unemployment.

Specification searches can be sensitive to the order restrictions are imposed, so the levels of the institutional variables were added to the final model and were not significant individually or jointly. The product of *dur* and *rr*, the change in *den* and the product of *coord* and *den* used by NN0, were also not significant. The current and lagged change and lagged level of either the second unemployment PC or the first investment PC were also not significant.

Institutions seem to influence adjustment to the global factor but have no influence on the natural rate, which is determined just by the global factor. But even after allowing for institutions there is substantial heterogeneity between countries. The institutional model in Table 4, has 28 parameters and an MLL of -727. The heterogeneous model of Table A2 has, for the 19 countries, 133 parameters and an MLL of -441. These models are not nested. The institutional model allows time-variation in the parameters but restricts between-country variation to that associated with institutional variables; the heterogeneous model allows parameters to differ freely over countries, which can pick up the effect of country specific institutions, but does not allow variation over time. They can however be compared using model selection criteria. The AIC would select the heterogeneous model; the BIC, which penalises over-parameterization more heavily, would select the institutional model. Given possible concerns about the quality of the institutional data it seems preferable to use the heterogeneous model which we do below.

5 The Phillips Curve

Section 4 showed that the global factor shifts the equilibrium level to which unemployment adjusts, thus it can be interpreted as a determinant of the natural rate. This prompts the question, how does it perform as a measure of the natural rate in a Phillips Curve? We return to the sample of 21 countries, since we are not using the institutional variables. (We investigated including the institutional variables in the Phillips Curve in the 19 country sample, but they were not significant, see Appendix A6) We assume that the natural rate is a function of the global factor as in (2) above

$$u_{it}^* = a_i + b_i f_t.$$

We also allow global inflation, measured by average inflation in the sample $\Delta\overline{p}_t$ to shift national inflation, perhaps because of global cost shocks or common monetary policy responses to shocks. There is a lot of evidence for global influences on the Phillips curve, see Dees et al. (2008).

Consider a model in which the change in inflation, $\Delta^2 p_{it}$, is determined by the deviation of unemployment from its natural rate, $u_{it} - (a_i + b_i f_t)$, the change in average inflation, $\Delta^2 \overline{p}_t$, and the deviation of lagged inflation from a function of the global average $(\Delta p_{it-1} - \theta_i \Delta\overline{p}_{t-1})$:

$$\Delta^2 p_{it} = -\beta_i (u_{it} - (a_i + b_i f_t)) + \gamma_i \Delta^2 \overline{p}_t - \lambda_i (\Delta p_{it-1} - \theta_i \Delta\overline{p}_{t-1}) + \varepsilon_{it} \quad (15)$$

We can parameterize (15) to test the hypothesis $\theta_i = 1$ by writing it as

$$\Delta^2 p_{it} = -\beta_i (u_{it} - (a_i + b_i f_t)) + \gamma_i \Delta^2 \overline{p}_t - \lambda_i \theta_i (\Delta p_{it-1} - \Delta\overline{p}_{t-1}) + \lambda_i (\theta_i - 1)\Delta p_{it-1} + \varepsilon_{it} \quad (16)$$

If $\theta_i = 1$, lagged inflation drops out of the equation.

Equation (16) was estimated separately for each country and the results are given in Appendix A7. The RCM and fixed effect estimates are shown in Table 5.

Table 5**:** The Phillips Curve.

Dependent variable $\Delta^2 p_{it}$, $N = 21$, $T = 1963 - 2002$				
	RCM		FE	
	Coefficient	t-ratio	coefficient	t-ratio
u_{it}	-0.464	-2.47	-0.194	-2.82
f_t	0.222	2.40	0.124	2.09
$\Delta^2 \overline{p}_t$	0.86	3.22	0.999	9.82
$\Delta p_{it-1} - \Delta\overline{p}_{t-1}$	-0.636	-4.87	-0.584	-12.05
Δp_{it-1}	0.008	0.077	0.005	0.13
Constant	2.00	4.15	---	---

Although homogeneity is strongly rejected, both, the RCM and fixed effect estimates have the right sign for every variable. Unemployment has a negative effect and the natural rate a positive effect. The change in world inflation has a coefficient close to one. There is rapid adjustment of inflation to average inflation, over half the deviation made up in a year. This is consistent with the literature on inflation convergence, e.g.

Hyvonen (2004). Lagged inflation is insignificant, which is required for consistency: averaging the equations over country must give average inflation. While we do not reject $\theta_i = 1$, on average, it is rejected in a number of countries. The RCM Phillips curve estimate of the average natural rate as a function of the global factor (which has mean zero over the sample) in percent is $u_t^* = 4.3 + 0.48 f_t$. The RCM unemployment adjustment estimate of the average natural rate from Table 2 is $u_t^* = 4.7 + 0.68 f_t$ which is similar. These are close and if one used the FE estimate of the effect of the global factor in the Phillips curve, $b = 0.64$, this would be very close to the FE estimate from the unemployment adjustment equation $b = 0.7$. Thus the estimates of the influence of the global factor on the natural rate in the two equations are broadly consistent. Using lagged values, u_{it-1} and f_{t-1} instead of current values gives similar results.

Looking at the individual countries, unemployment has a negative sign in all but Denmark and Portugal. The global factor has a positive sign in all but Denmark, Finland and Japan. The lagged deviation of inflation from the average always has a negative sign. Lagged inflation has mixed positive and negative signs and is significant in 12 countries, rejecting $\theta_i = 1$. The minimum R squared is 0.38 in Austria, the maximum 0.79 in Canada. Fifteen countries have an R squared over 0.5.

The hypothesis that the natural rate of unemployment is determined by the global factor implies cross-equation restrictions on the unemployment adjustment and Phillips curve equations, since the natural rate, $u_{it}^* = a_i + b_i f_t$, appears in both. The two equation system was estimated for each country and the cross-equation restriction tested. The system is given by equations (13) and (16), which simplifying the notation is

$$\Delta u_{it} = d_i(a_i + b_i f_{t-1} - u_{i,t-1}) + c_i \Delta f_t + e_{1i}\Delta f_{t-1} + e_{2i}\Delta u_{i,t-1} + e_{3i}\Delta p_{it-1} + \varepsilon^1_{it} \tag{17}$$

$$\Delta^2 p_{it} = -\beta_i(u_{it} - (a_i + b_i f_t)) + \gamma_i \Delta^2 \overline{p}_t - \delta_i(\Delta p_{it-1} - \Delta\overline{p}_{t-1}) + \eta_i \Delta p_{it-1} + \varepsilon^2_{it} \tag{18}$$

Notice that the system is recursive, current unemployment influences inflation, but current inflation does not influence unemployment. The cross-equation restriction is that the a_i, b_i in the two equations are the same. The interpretation that the intercept in (18) measures $\beta_i a_i$ requires that domestic inflation is proportional to average inflation, $\theta_i = 1$, as assumed above. Otherwise, if the last term in (15) were $(\Delta p_{it-1} - \Delta p^*_i - \theta_i \Delta\overline{p}_{t-1})$, there will be a term in domestic equilibrium inflation included in the intercept. This may lead to the cross-equation restriction being rejected.

The two equations were estimated as a system for all 21 countries allowing for the covariance between $(\varepsilon^1_{it}, \varepsilon^2_{it})$. The cross-equation restrictions were rejected only for France, Italy and Portugal[15]. However, in Austria, Denmark and Finland the constrained system produced estimates of d_i and β_i very close to zero, so that a_i and b_i were not identified. Thus the cross-equation restrictions implied by the model can be accepted in 15 out of the 21 countries: the globally determined natural rate in the Phillips Curve is the same natural rate to which unemployment is adjusting. In the countries with identified estimates, a_i ranged from 2.48 in Iceland to 8.77 in Spain, b_i ranged from -0.31 for Japan (the only negative estimate), 0.18 in the US to 1.49 in Spain. The estimates are given in Appendix A8.

[15] The Likelihood ratio test statistics were 10.93, 9.52 and 10.45 respectively, with a 5% critical value of 5.99.

The inflation equation, (18), can be interpreted as an expectations-augmented Phillips curve by writing it;

$$\Delta p_{it} = \phi_i E_{t-1}(\Delta p_{it}) - \beta_i (u_{it} - (a_i + b_i f_t)) + \gamma_i \Delta \bar{p}_t + \varepsilon^2{}_{it} \quad (19)$$

$$E_{t-1}(\Delta p_{it}) = \pi_i ' x_{it-1} \quad (20)$$

where x_{it-1} is a set of variables observed at time t-1. This allows us to test both $\phi_i = 1$ and the cross-equation restrictions implied by rational expectations: x_{it-1} only enters the Phillips curve through inflation expectations:

$$\Delta p_{it} = \phi_i E_{t-1}(\pi_i ' x_{it}) - \beta_i (u_{it} - (a_i + b_i f_t)) + \gamma_i \Delta \bar{p}_t + \varepsilon^2{}_{it} . \quad (21)$$

The three equation system, (17), (19), (20) was estimated separately on the 21 countries imposing the natural rate restriction with various specifications of x_{it-1}. As one would expect, results were sensitive to the choice of x_{it-1}. We will comment on those just using lagged inflation and lagged average inflation, which is consistent with the model of A3. The $\phi_i = 1$ and the rational expectations restrictions were rejected by relatively few countries. For instance, $\phi_i = 1$ was rejected only in Belgium, France, Ireland and the UK. However, the standard errors of both ϕ_i and π_i were large in some cases so the tests may not have high power. Although the estimates are not inconsistent with a vertical Phillips Curve, while β_i was usually the right sign in the restricted system, it was rarely significant. For the same x_{it-1} it was positive in only Austria, Germany and Portugal, but significantly negative in only Belgium, UK and US. The reason for this seems to be that the term $(u_{it} - (a_i + b_i f_t))$ is very persistent and thus predictable and its predictable component is captured by $E_{t-1}(\Delta p_{it})$ leaving the realization of the deviation of unemployment from its natural rate insignificant. In fact rejection of $\phi_i = 1$ seemed to be more common when β_i was significant. When the system was estimated imposing all four restrictions, the two implied by a common natural rate, $\phi_i = 1$ and the restriction implied by rational expectations, the joint restrictions were rejected in 11 of the 21 countries.[16] Therefore it seems more useful to work with the estimates in Appendix A7, where rational expectations are not imposed and the deviation of unemployment from its natural rate is significant in many countries.

A simple Phillips curve, assuming a common form of equation in each country, works quite well, once one takes account of global factors, both in determining the natural rate and in influencing national inflation. When the Phillips curve was estimated together with the unemployment adjustment equation as a system, the hypothesis that the same natural rate, $u_{it}^* = a_i + b_i f_t$, appeared in both equations could not be rejected in 15 out of the 21 countries. The data are also consistent for many countries with a vertical Phillips Curve and rational expectations, though when these restrictions are imposed, the deviation of unemployment from its natural rate tends to become insignificant.

[16] Belgium, Denmark, France, Germany, Greece, Iceland, Italy, Japan, Norway, Spain and Sweden.

6 Conclusions

There is a large common component in OECD unemployment, which accounts for about 70% of the total variance. This common component is a very persistent series; is almost identical to the common component in investment shares and explains a substantial amount of national unemployment variation. It has a natural interpretation in terms of the global expected return on production and is consistent with a variety of sunspot or animal spirit models. We propose a simple model of unemployment adjustment and allow five measures of labour market institutions to influence unemployment; (a) through the equilibrium level of unemployment; (b) through the long-run effect of the global factor on the equilibrium level of unemployment; (c) through the impact of shocks to the global factor on the change in unemployment and (d) the speed of adjustment to equilibrium. We find that the institutional variables have no effect on the equilibrium level of unemployment; that increased coordination reduces the speed of adjustment; that increased employment protection reduces the short run effect of changes in the global factor but increases the long run effect; and that a higher replacement ratio increases the short run effect of changes in the global factor. However a model without institutions but which allowed for more cross-country heterogeneity was selected by the AIC, though not the BIC.

Conditional on our measure of global factors, it appears that labour market institutions influence the transmission of global influences rather than determining the equilibrium level of unemployment which is determined by the global factor. Given this we examined a Phillips Curve in which the natural rate is determined by the global factor and where equilibrium inflation adjusts to the global average inflation rate. This worked well and on average we found a vertical Phillips Curve once one allowed for global influences on the natural rate. When the Phillips curve and unemployment adjustment equations were estimated as a system, the hypothesis that the same natural rate appeared in both could not be rejected in 15 out of the 21 countries. Idiosyncratic factors are important. Although the equations have a common form, the parameters differ significantly across countries. In explaining both unemployment and inflation, global factors are very significant suggesting that models which ignore them are likely to be deficient.

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Appendix A1: Eigenvectors for Unemployment and Investment

	First PC		*Second PC*		*Third PC*		*Fourth PC*	
	U	*G*	*U*	*G*	*U*	*G*	*U*	*G*
Australia	0.252	0.220	0.100	-0.035	0.040	0.196	-0.019	-0.044
Austria	0.235	0.253	-0.209	0.002	-0.019	-0.113	0.205	-0.208
Belgium	0.246	0.231	0.123	-0.074	-0.253	-0.384	-0.020	0.093
Canada	0.228	0.251	0.210	0.126	0.135	0.135	-0.002	0.144
Denmark	0.234	0.260	0.185	-0.169	0.133	0.089	-0.034	-0.028
Finland	0.219	0.228	-0.194	0.116	0.097	0.114	-0.425	0.177
France	0.258	0.276	-0.022	-0.016	-0.104	-0.101	0.026	-0.054
Germany	0.247	0.186	-0.130	-0.350	-0.183	-0.050	0.052	-0.411
Greece	0.193	0.221	-0.285	0.273	-0.103	-0.144	0.367	-0.138
Iceland	0.191	0.248	-0.231	0.072	0.382	-0.057	-0.342	0.130
Ireland	0.183	0.123	0.311	0.486	0.216	-0.239	0.220	-0.074
Italy	0.244	0.241	-0.130	-0.008	-0.153	0.125	0.122	-0.172
Japan	0.180	0.233	-0.226	-0.156	-0.482	-0.111	0.007	-0.233
Netherlands	0.211	0.231	0.295	-0.311	-0.047	-0.091	0.082	-0.123
New Zeal.	0.218	0.172	-0.1376	0.162	0.410	0.370	0.135	0.206
Norway	0.239	0.212	-0.0996	0.098	0.210	0.323	0.215	0.194
Portugal	0.154	0.010	0.2901	0.464	-0.345	-0.090	-0.474	-0.270
Spain	0.256	0.175	0.0256	-0.046	-0.107	-0.417	0.057	0.496
Sweden	0.199	0.257	-0.2545	-0.191	0.130	0.040	-0.400	0.113
UK	0.234	0.226	0.2212	0.035	-0.045	-0.013	0.026	0.255
US	0.085	0.166	0.4292	0.290	0.147	0.343	-0.003	-0.308

Appendix A2: Unemployment Equations by Country: Coefficients.

Dependent variable change in unemployment
Coefficients and t ratios, bold if t>2

		Δf_t	f_{t-1}	Δf_{t-1}	u_{t-1}	Δu_{t-1}	π_{t-1}	a_i
1	Australia	**0.94**	**0.43**	-0.26	**-0.59**	0.27	**7.23**	**2.83**
		(7.00)	(4.13)	(1.54)	(4.31)	(1.89)	(2.93)	(3.93)
2	Austria	**0.26**	**0.08**	-0.12	**-0.14**	0.11	1.96	0.38
		(4.38)	(3.19)	(1.50)	(2.10)	(0.61)	(0.64)	(1.30)
3	Belgium	**0.57**	**0.15**	-0.17	**-0.17**	**0.44**	**7.69**	**0.70**
		(5.14)	(2.79)	(1.13)	(3.04)	(3.31)	(2.20)	(2.25)
4	Canada	**0.99**	**0.17**	-0.19	**-0.33**	0.09	4.88	**2.18**
		(6.52)	(2.80)	(0.92)	(3.15)	(0.60)	(1.69)	(2.78)
5	Denmark	**0.95**	0.15	**-0.50**	-0.23	0.27	6.89	0.60
		(6.52)	(1.57)	(2.93)	(1.82)	(1.86)	(1.67)	(1.27)
6	Finland	**1.10**	**0.14**	-0.52	**-0.17**	**0.66**	-5.18	**1.30**
		(4.85)	(2.26)	(1.79)	(3.02)	(5.00)	(1.06)	(2.56)
7	France	**0.52**	**0.44**	-0.26	**-0.43**	0.17	3.23	**2.82**
		(5.29)	(4.53)	(1.91)	(4.58)	(1.26)	(1.59)	(4.44)
8	Germany	**0.65**	0.05	-0.26	-0.03	0.35	4.69	0.04
		(5.63)	(0.79)	(1.48)	(0.33)	(1.80)	(0.82)	(0.10)
9	Greece	**0.60**	**0.16**	**-0.34**	**-0.17**	**0.55**	-3.47	**1.37**
		(4.30)	(3.25)	(2.36)	(2.90)	(3.74)	(1.84)	(2.69)
10	Iceland	0.21	**0.06**	0.22	**-0.32**	0.20	**-1.28**	**0.83**
		(1.70)	(2.18)	(1.69)	(3.09)	(1.31)	(2.41)	(3.12)
11	Ireland	**1.15**	-0.04	0.06	0.00	-0.20	6.91	-0.69
		(3.52)	(0.48)	(0.16)	(0.01)	(1.10)	(1.43)	(0.86)
12	Italy	0.15	**0.29**	-0.10	**-0.38**	**0.29**	-1.63	**2.91**
		(1.21)	(4.26)	(0.70)	(4.26)	(2.17)	(1.03)	(4.16)
13	Japan	0.08	0.02	-0.06	0.04	0.35	2.38	-0.13
		(1.44)	(1.67)	(0.97)	(0.65)	(1.76)	(1.90)	(0.79)
14	Netherlands	**0.73**	0.07	-0.21	**-0.13**	**0.57**	2.34	0.40
		(5.68)	(1.71)	(1.20)	(2.62)	(4.13)	(0.51)	(1.35)
15	New Zealand	**0.54**	0.10	**-0.59**	-0.12	**0.45**	4.37	0.16
		(2.43)	(0.90)	(3.49)	(0.84)	(2.86)	(1.16)	(0.24)
16	Norway	**0.47**	**0.10**	**-0.35**	**-0.29**	**0.63**	-1.60	0.89
		(4.45)	(2.72)	(3.57)	(2.57)	(4.57)	(0.47)	(1.94)
17	Portugal	0.18	**0.08**	0.20	**-0.31**	**0.56**	**3.95**	**1.27**
		(1.01)	(2.30)	(1.14)	(4.36)	(4.72)	(2.07)	(3.91)
18	Spain	**0.64**	**0.49**	-0.17	**-0.32**	**0.58**	1.60	**2.71**
		(4.37)	(4.07)	(0.87)	(4.24)	(5.61)	(0.69)	(3.86)
19	Sweden	**0.79**	**0.07**	-0.22	**-0.16**	**0.44**	-7.31	**0.88**
		(5.21)	(2.09)	(1.25)	(2.15)	(2.76)	(1.85)	(2.20)
20	UK	**0.70**	**0.15**	**-0.39**	**-0.18**	**0.47**	**6.81**	0.58
		(3.89)	(2.27)	(2.06)	(2.56)	(3.07)	(2.70)	(1.37)
21	US	**0.70**	0.04	**-0.37**	**-0.32**	0.03	**16.05**	**1.15**
		(4.37)	(1.60)	(2.21)	(3.79)	(0.23)	(4.20)	(2.38)

Appendix A2 continued: Unemployment Equations by Country Diagnostic Statistics

		SER	LL	R^2	FLR
1	Australia	0.50	-25.28	0.75	9.96
2	Austria	0.22	7.87	0.61	6.86
3	Belgium	0.41	-16.79	0.78	4.93
4	Canada	0.57	-30.45	0.70	5.26
5	Denmark	0.52	-26.67	0.69	1.92
6	Finland	0.84	-45.98	0.73	4.83
7	France	0.34	-9.61	0.74	11.11
8	Germany	0.39	-15.65	0.70	1.47
9	Greece	0.44	-20.27	0.65	5.63
10	Iceland	0.47	-22.59	0.44	5.06
11	Ireland	1.19	-59.79	0.52	0.30
12	Italy	0.37	-13.05	0.66	9.78
13	Japan	0.18	14.59	0.38	3.16
14	Netherlands	0.49	-24.09	0.77	3.71
15	New Zealand	0.63	-34.33	0.52	0.43
16	Norway	0.36	-12.00	0.59	4.00
17	Portugal	0.62	-33.56	0.66	10.27
18	Spain	0.56	-29.76	0.83	9.60
19	Sweden	0.52	-26.49	0.65	2.73
20	UK	0.61	-32.83	0.73	3.48
21	US	0.52	-27.13	0.73	7.64

SER is standard error of regression, LL maximised Log likelihood, FLR is the F statistic for excluding lagged unemployment and lagged global factor.

Appendix A3: Swamy RCM Procedure

Write the heterogeneous model as

$$y_i = W_i \delta_i + u_i$$

where y_i is a T×1 vector, and W_i is a T×(k+1) vector. The fixed effect estimator constrains the *k* slopes to be the same. The parameters are assumed to be random, $\delta_i = \delta + \eta_i$ where $E(\eta_i) = 0,\ E(\eta_i \eta_j) = \Omega, i = j,\ E(\eta_i \eta_j) = 0,$ otherwise, and the η_i are independent of W_i. There are a large number of estimators for the expected value of the random coefficients. The simplest one consists of computing the OLS estimates for each country $\hat{\delta}_i$ and then constructing the average $\bar{\delta} = \sum_i \hat{\delta}_i / N$, estimating the (*k*+1)×(*k*+1) covariance matrix Ω by

$$\hat{\Omega} = \sum_i (\hat{\delta}_i - \bar{\delta})(\hat{\delta}_i - \bar{\delta})'/(N-1)$$

Pesaran and Smith (1995) call this the Mean Group estimator. Its covariance matrix is

$$V(\bar{\delta}) = \hat{\Omega} / N$$

Swamy (1970) suggests a feasible GLS estimator, which is equivalent to using a weighted average of the individual OLS estimates instead of the unweighted average. Define the residuals, the unbiased estimate of the variance and the estimated variance covariance matrix as follows

$$\hat{u}_i = y_i - W_i \hat{\delta}_i;\ \ s_i^2 = \hat{u}_i \hat{u}_i'/(T-k-1),\ V(\hat{\delta}_i) = s_i^2 (W_i' W_i)^{-1}.$$

Swamy suggests estimating Ω by

$$\tilde{\Omega} = \hat{\Omega} - \sum_i V(\hat{\delta}_i) / N$$

If this estimator is not positive definite (which it rarely is), the last term is set to zero and $\hat{\Omega}$ used. The Swamy estimator of the mean is

$$\tilde{\delta} = \sum_i D_i \hat{\delta}_i,\quad D_i = \left\{ \sum_i \left[\tilde{\Omega} + V(\hat{\delta}_i) \right]^{-1} \right\}^{-1} \left[\tilde{\Omega} + V(\hat{\delta}_i) \right]^{-1},\ V(\hat{\delta}_i) = \left\{ \sum_i \left[\tilde{\Omega} + V(\hat{\delta}_i) \right]^{-1} \right\}^{-1}$$

Notice that the Swamy estimator of the standard errors is non-parametric it depends on the distribution of the $\hat{\delta}_i$ and therefore is likely to be robust to serial correlation and heteroskedasticity.

The Swamy RCM can be interpreted either as a GLS estimator or an empirical Bayes estimator. The homogeneity hypothesis $H_o : \delta_i = \delta$ can be tested by the Wald test suggested by Swamy

$$S = \sum_i (\hat{\delta}_i - \delta_*)' V(\hat{\delta}_i)(\hat{\delta}_i - \delta_*) \sim \chi^2 (k+1)(N-1)$$

where $\delta_* = \left[\sum_i V(\hat{\delta}_i)^{-1}\right]^{-1} V(\hat{\delta}_i)^{-1}\hat{\delta}_i$ is a feasible GLS fixed effect estimator. The desirable properties of this test depend on *T* being large relative to *N*, which is the case in our application.

Appendix A4: Alternative Measures of the Global Factor

The correlation of the first PC of unemployment with mean unemployment is 0.998 and with the first PC of investment factor -0.961. The correlation between the investment PC and mean unemployment is -0.952. The second PC of unemployment is uncorrelated with the first and has correlations of -0.07 with both the first PC of investment and mean unemployment.

Below in sequence are given (a) the two way fixed effect estimates which allow for an implicit unobserved factor by adding 39 free time dummies, then the Swamy RCM and Fixed Effects estimates using as factors (b) the first PC of unemployment (given in the text), (c) the first PC of investment, (d) average unemployment across the OECD sample (e) the first and second PCs of unemployment.

Table A4a: Two Way Fixed Effects Model

Dependent variable Δu_{it}, $N = 21$, $T = 1963-2002$		
	FE MLL=-814.79	
	coefficient	t-ratio
u_{it-1}	-0.10	8.21
Δu_{it-1}	0.44	13.64
Δp_{it-1}	0.01	1.45

Table A4b: First Unemployment Factor

Dependent variable Δu_{it}, $N = 21$, $T = 1963-2002$: FE MLL=-817.80				
	RCM		FE	
	coefficient	t-ratio	Coefficient	t-ratio
Δf_t	0.59	8.8	0.62	13.3
f_{t-1}	0.12	4.0	0.07	7.0
Δf_{t-1}	-0.23	6.0	-0.27	5.8
u_{it-1}	-0.18	5.8	-0.10	9.0
Δu_{it-1}	0.38	8.0	0.44	9.1
Δp_{it-1}	0.82	2.7	0.69	1.6

Table A4c: First PC of Investment

Dependent variable Δu_{it}, $N=21$, $T=1963-2002$; FE MLL=-862.30				
	RCM		FE	
	coefficient	t-ratio	Coefficient	t-ratio
Δf_t	-0.24	6.97	-0.26	7.90
f_{t-1}	-0.11	3.87	-0.06	0.94
Δf_{t-1}	0.03	0.71	-0.00	0.05
u_{it-1}	-0.17	5.78	-0.11	7.31
Δu_{it-1}	0.39	7.54	0.45	10.01
Δp_{it-1}	0.67	3.33	0.01	0.38

Table A4d: Mean Unemployment

Dependent variable Δu_{it}, $N=21$, $T=1963-2002$; FE MLL=-815.16				
	RCM		FE	
	coefficient	t-ratio	Coefficient	t-ratio
$\Delta \bar{u}_t$	.95	8.15	0.98	9.14
$\bar{u}_{t-1}$	.20	3.82	0.10	0.40
$\Delta \bar{u}_{t-1}$	-.38	5.88	-0.45	-3.70
u_{it-1}	-.18	5.51	-0.10	-4.65
Δu_{it-1}	.37	8.20	0.44	2.00
Δp_{it-1}	-.13	-1.08	0.01	0.05

Table A4e: First Two PCs of Unemployment, f_t^1 and f_t^2

Dependent variable Δu_{it}, $N=21$, $T=1963-2002$; FE MLL=-817.65				
	RCM		FE	
	coefficient	t-ratio	Coefficient	t-ratio
Δf_t^1	0.58	8.48	0.61	2.97
f_{t-1}^1	0.19	4.58	0.07	0.43
Δf_{t-1}^1	-0.24	3.41	-0.26	0.63
Δf_t^2	-0.06	0.42	-0.03	0.41
f_{t-1}^2	-0.05	0.72	-0.00	0.00
Δf_{t-1}^2	-0.03	0.35	0.02	0.43
u_{it-1}	-0.29	6.23	-0.10	0.40
Δu_{it-1}	0.41	6.70	0.44	1.58
Δp_{it-1}	0.78	0.44	0.01	0.47

Appendix A5: Institutions and Unemployment Adjustment –
Table 4: Unrestricted Model

The estimates in Table 4 are of a restricted version of a model allowing institutions to influence all the coefficients. The unrestricted version is shown below, which has a MLL of -714.3 with 27 parameters. The restricted model in Table 4 has a MLL of -727 with 12 parameters, so the restrictions are jointly accepted. Unemployment is measured as a deviation from the country mean to allow for fixed effects.

$$\begin{aligned}\Delta\widetilde{u}_{it} = & \left[a_0 + a_1 coord + a_2 emp + a_3 den + a_4 rr + a_5 dur\right] \\ & + \left[d_0 + d_1 coord + d_2 emp + d_3 den + d_4 rr + d_5 dur\right] \\ & * \left[\left(b_0 + b_1 coord + b_2 emp + b_3 den + b_4 rr + b_5 dur\right) f_{t-1} - \widetilde{u}_{i,t-1}\right] \\ & + \left[c_0 + c_1 coord + c_2 emp + c_3 den + c_4 rr + c_5 dur\right] * \Delta f_t \\ & + e_1 \Delta f_{t-1} + e_2 \Delta\widetilde{u}_{i,t-1} + e_3 \Delta p_{i,t-1} + \varepsilon_{it}\end{aligned}$$

Dependent variable $\Delta\tilde{u}_{it}$, $N = 19$, $T = 1963 - 2002$, obs. = 760

	coefficient	t-ratio		coefficient	t-ratio
a_0	1.15	-0.13	d_0	0.46	6.20
a_1	-0.01	0.12	d_1	-0.07	3.18
a_2	0.06	0.90	d_2	-0.07	2.34
a_3	-0.002	1.41	d_3	-0.00	0.01
a_4	-0.11	0.79	d_4	-0.11	1.48
a_5	0.03	0.39	d_5	-0.09	2.06
b_0	-0.25	1.48	e_1	-0.26	5.08
b_1	-0.05	0.59	e_2	0.38	7.19
b_2	0.38	4.31	e_3	0.03	3.95
b_3	0.01	1.79			
b_4	0.85	3.35			
b_5	0.43	3.76			
c_0	0.51	2.89			
c_1	0.03	0.33			
c_2	-0.29	2.81			
c_3	0.002	1.09			
c_4	0.63	3.45			
c_5	0.08	0.66			

$R^2 = 0.54$, $SER = 0.62$ MLL = -714.

It is noticeable that coefficients, b_4 and b_5 and d_4 and d_5 that are significant in the unrestricted model become insignificant during the sequential search and are not included in the restricted model. The individual significance seems to be the result of a high correlation between the variables causing cancelling out, so if one is dropped the other loses significance. When they are introduced individually in the final model they are not significant.

Appendix A6: Phillips Curve with Labour Market Institutions (LMI)

The Phillips Curve in the text was estimated allowing LMI variables to influence the parameters, using deviations from the mean for inflation to allow for fixed effects as with unemployment. The equation was:

$$\begin{aligned}\Delta^2 \tilde{p}_{it} = & \left[a_0 + a_1 coord + a_2 emp + a_3 den + a_4 rr + a_5 dur\right] \\ & + \left[d_0 + d_1 coord + d_2 emp + d_3 den + d_4 rr + d_5 dur\right] \\ & * \left[u_{it} - \left(b_0 + b_1 coord + b_2 emp + b_3 den + b_4 rr + b_5 dur\right) f_t\right] \\ & + e_1 \Delta\overline{p}_t + e_2 \Delta\tilde{p}_{i,t-1} + e_3 \Delta\overline{p}_{t-1} + \varepsilon_{it}\end{aligned}$$

Dependent variable $\Delta^2 p_{it}$, $N = 19$, $T = 1963 - 2002$, obs. = 760

	coefficient	t-ratio		coefficient	t-ratio
a_0	-1.56	2.61	d_0	-0.12	1.78
a_1	0.14	0.61	d_1	-0.03	1.13
a_2	-0.56	1.86	d_2	0.08	2.19
a_3	0.00	0.08	d_3	0.00	1.34
a_4	-0.20	0.31	d_4	0.02	0.36
a_5	-0.27	0.80	d_5	0.02	0.54
b_0	0.10	0.10	e_1	0.65	8.75
b_1	1.58	1.94	e_2	-0.46	7.88
b_2	-2.51	2.00	e_3	0.38	6.44
b_3	-0.05	1.33			
b_4	-0.73	0.23			
b_5	0.79	0.83			

$R^2 = 0.36$, *SER* = 1.98, *MLL* =.-1598

The institutional effects do not seem significant.

Appendix A7: Phillips Curves by Country

Dependent variable change in inflation
Coefficients in bold if t ratio>2

		u_{it}	f_t	$\Delta^2 \overline{p}_t$	$\Delta p_{it-1} - \Delta \overline{p}_t$	Δp_{it-1}	int	SER	R^2
1	Australia	-0.81	0.63	**0.86**	**-0.50**	0.07	3.77	1.51	0.54
		(1.96)	(1.96)	(4.54)	(3.29)	(0.70)	(1.93)		
2	Austria	-0.41	0.06	**0.29**	-0.13	**-0.45**	2.54	1.09	0.38
		(0.79)	(0.30)	(2.02)	(1.09)	(3.22)	(1.16)		
3	Belgium	**-0.38**	**0.31**	**0.74**	**-0.34**	-0.08	**1.75**	0.90	0.70
		(2.39)	(2.19)	(6.57)	(3.28)	(1.30)	(2.30)		
4	Canada	**-0.97**	0.49	0.01	**-1.34**	-0.14	5.42	2.15	0.79
		(2.09)	(1.71)	(0.05)	(7.74)	(1.02)	(1.84)		
5	Denmark	0.02	-0.28	**0.71**	**-0.45**	**-0.31**	1.46	1.45	0.53
		(0.05)	(1.23)	(3.91)	(3.05)	(2.59)	(1.53)		
6	Finland	-0.01	-0.21	**0.73**	**-0.60**	-0.11	0.35	1.85	0.52
		(0.05)	(1.30)	(3.19)	(3.52)	(1.22)	(0.29)		
7	France	-0.09	0.05	**0.79**	**-0.49**	-0.05	0.19	0.97	0.64
		(0.38)	(0.21)	(6.11)	(3.46)	(1.14)	(0.11)		
8	Germany	**-0.32**	0.22	**0.43**	-0.01	**-0.29**	**2.12**	0.79	0.53
		(2.29)	(1.97)	(4.30)	(0.25)	(3.55)	(2.76)		
9	Greece	-0.24	0.72	**1.50**	**-0.81**	0.26	1.91	3.31	0.42
		(0.49)	(1.87)	(3.49)	(2.27)	(0.95)	(0.42)		
10	Iceland	-3.89	1.48	**5.94**	**-2.62**	**1.73**	6.47	11.47	0.66
		(1.53)	(1.95)	(4.01)	(3.36)	(2.52)	(0.81)		
11	Ireland	**-0.41**	0.22	**0.91**	**-1.05**	**0.30**	**2.27**	1.73	0.59
		(3.48)	(1.70)	(4.22)	(4.52)	(2.78)	(2.45)		
12	Italy	-0.31	0.35	**1.13**	**-0.99**	**0.22**	1.47	1.70	0.57
		(0.97)	(1.34)	(5.03)	(4.33)	(2.09)	(0.55)		
13	Japan	-0.69	-0.12	**0.93**	-0.18	**-0.35**	**2.56**	1.83	0.53
		(1.83)	(0.95)	(4.12)	(1.61)	(3.38)	(2.09)		
14	Netherlands	**-0.43**	0.10	**0.44**	**-0.30**	**-0.28**	**2.30**	1.26	0.49
		(2.33)	(0.82)	(2.84)	(2.64)	(2.87)	(3.45)		
15	New Zealand	**-0.79**	**0.56**	0.54	**-0.62**	-0.02	**3.13**	2.26	0.48
		(2.79)	(2.28)	(1.92)	(3.41)	(0.21)	(2.12)		
16	Norway	**-0.80**	0.14	**0.39**	**-0.60**	**-0.37**	**3.60**	1.59	0.58
		(2.39)	(1.11)	(2.02)	(4.79)	(3.86)	(2.83)		
17	Portugal	0.20	0.12	0.52	**-1.46**	**0.64**	-1.88	3.48	0.49
		(0.47)	(0.56)	(1.17)	(4.67)	(3.07)	(0.94)		
18	Spain	-0.35	0.39	0.40	**-0.61**	0.08	3.51	1.96	0.39
		(1.59)	(1.09)	(1.61)	(3.51)	(0.84)	(1.69)		
19	Sweden	**-0.44**	0.17	**0.66**	**-0.54**	**-0.24**	**2.30**	1.53	0.60
		(2.16)	(1.52)	(3.47)	(3.97)	(2.68)	(2.13)		
20	UK	**-0.84**	**0.64**	**1.19**	**-0.91**	**0.25**	**3.04**	1.86	0.65
		(2.82)	(2.55)	(5.10)	(4.15)	(2.13)	(2.36)		
21	US	**-0.91**	**0.18**	**0.87**	**-0.54**	0.06	**4.02**	1.01	0.73
		(4.16)	(2.82)	(6.69)	(4.95)	(0.64)	(4.54)		
	Mean	-0.61	0.3	0.95	-0.72	0.04	2.49		
	Sum MLL	-1529.29							

Appendix A8: Identified Systems Estimates for Change in Unemployment and Change in Inflation Equations

		d	a	b	c	e1	e2	e3
1	Australia	**0.61**	**4.81**	**0.74**	**0.96**	-0.28	**0.31**	**0.07**
		(4.55)	(14.14)	(12.88)	(7.00)	(1.44)	(2.20)	(2.20)
2	Austria *							
3	Belgium	**0.17**	**4.37**	**0.86**	**0.58**	-0.17	**0.45**	0.07
		(2.64)	(5.93)	(8.91)	(4.91)	(0.72)	(2.62)	(1.31)
4	Canada	0.24	**5.98**	**0.52**	**0.95**	-0.22	0.04	0.06
		(1.61)	(6.83)	(4.09)	(5.08)	(0.92)	(0.21)	(1.83)
5	Denmark *							
6	Finland *							
7	France	**0.44**	**6.49**	**1.01**	**0.51**	-0.27	0.17	0.03
		(3.33)	(13.65)	(18.94)	(3.10)	(1.19)	(0.73)	(0.90)
8	Germany	0.01	**6.28**	**0.65**	**0.61**	-0.25	**0.47**	0.01
		(0.10)	(5.16)	(6.24)	(5.37)	(1.61)	(2.77)	(0.27)
9	Greece	**0.15**	**8.50**	**1.09**	**0.62**	-0.31	**0.51**	-0.04
		(2.12)	(6.85)	(3.21)	(2.92)	(1.29)	(2.62)	(1.98)
10	Iceland	**0.31**	**2.48**	**0.24**	0.22	0.20	0.20	-0.01
		(2.54)	(6.50)	(2.22)	(1.01)	(0.76)	(0.80)	(1.90)
11	Ireland	0.08	**5.53**	**0.56**	**1.28**	-0.02	-0.07	0.03
		(1.37)	(2.82)	(2.42)	(3.60)	(0.06)	(0.44)	(0.77)
12	Italy	**0.37**	**7.51**	**0.78**	0.12	-0.09	0.27	-0.01
		(3.22)	(16.09)	(12.35)	(0.42)	(0.33)	(0.81)	(0.30)
13	Japan	(0.06	**3.22**	-0.31	0.08	-0.05	0.35	0.03
		(0.84)	(2.12)	(0.54)	(1.12)	(0.69)	(1.92)	(1.41)
14	Netherlands	**0.13**	**4.60**	0.35	**0.73**	-0.17	**0.61**	-0.02
		(2.52)	(4.68)	(1.78)	(5.81)	(0.78)	(4.50)	(0.54)
15	New Zealand	0.17	**3.05**	**0.77**	**0.57**	**-0.63**	**0.48**	0.02
		(1.38)	(2.67)	(4.16)	(2.43)	(3.40)	(2.93)	(0.87)
16	Norway	0.32	**3.55**	**0.29**	**0.48**	-0.31	**0.64**	-0.04
		(1.61)	(6.64)	(3.27)	(2.58)	(1.84	(3.67)	(0.80)
17	Portugal	0.31	**4.12**	0.25	0.18	0.20	0.56	0.04
		(1.96)	(4.13)	(1.16)	(0.60)	(0.67	(1.60)	(0.92)
18	Spain	**0.32**	**8.77**	**1.49**	**0.62**	-0.17	**0.59**	0.01
		(2.28)	(10.10)	(13.70)	(3.87)	(0.83)	(5.59)	(0.28)
19	Sweden	0.15	**5.10**	**0.43**	**0.73**	-0.20	**0.41**	-0.06
		(1.86)	(5.34)	(3.26)	(5.55)	(0.89)	(2.50)	(1.95)
20	UK	**0.20**	**3.60**	**0.78**	**0.71**	-0.38	**0.49**	0.06
		(3.26)	(3.76)	(5.25)	(3.77)	(1.81)	(3.13)	(2.37)
21	US	**0.36**	**4.20**	**0.18**	**0.75**	-0.38	0.08	**0.13**
		(3.36)	(11.51)	(3.04)	(2.84)	(1.79)	(0.45)	(3.53)

* Natural rate parameters not identified.

Appendix A8 continued

	β	γ	δ	η	R^2 Δu_{it}	R^2 $\Delta^2 p_{it}$
1 Australia	-1.15	**0.78**	**-0.49**	0.09	0.75	0.53
	(1.70)	(5.22)	(2.92)	(0.90)		
2 Austria*						
3 Belgium	-0.37	**0.75**	**-0.34**	-0.07	0.77	0.7
	(1.75)	(8.84)	(3.01)	(0.99)		
4 Canada	-1.37	0.00	**-1.37**	-0.09	0.69	0.78
	(1.46)	(0.00)	(7.33)	(0.39)		
5 Denmark*						
6 Finland*						
7 France	-0.14	**0.81**	**-0.37**	**-0.08**	0.74	0.60
	(0.46)	(11.81)	(3.56)	(2.73)		
8 Germany	**-0.38**	**0.43**	-0.02	**-0.31**	0.68	0.52
	(2.02)	(3.63)	(0.42)	(2.56)		
9 Greece	-0.69	**1.27**	-0.46	0.01	0.65	0.39
	(1.74)	(3.53)	(1.27)	(0.05)		
10 Iceland	-4.60	**5.19**	-2.19	1.29	0.43	0.65
	(0.85)	(4.86)	(1.82)	(1.38)		
11 Ireland	**-0.47**	**0.91**	**-1.13**	**0.34**	0.48	0.59
	(2.75)	(3.38)	(3.56)	(2.43)		
12 Italy	-0.32	**0.95**	**-0.75**	0.09	0.66	0.54
	(0.65)	(4.15)	(3.33)	(1.07)		
13 Japan	-0.56	**0.94**	**-0.25**	**-0.30**	0.38	0.52
	(0.85)	(5.87)	(2.59)	(4.22)		
14 Netherlands	-0.46	**0.49**	**-0.33**	**-0.23**	0.76	0.48
	(1.86)	(2.39)	(3.64)	(2.98)		
15 New Zealand	-0.56	0.55	**-0.64**	0.05	0.51	0.47
	(1.32)	(1.90)	(4.02)	(0.53)		
16 Norway	-0.91	0.52	**-0.65**	**-0.28**	0.57	0.55
	(1.74)	(1.58)	(3.15)	(2.48)		
17 Portugal	0.21	0.30	**-1.23**	**0.47**	0.66	0.47
	(0.49)	(0.87)	(3.54)	(3.22)		
18 Spain	-0.37	0.55	**-0.64**	0.12	0.83	0.36
	(1.45)	(1.23)	(2.49)	(1.20)		
19 Sweden	**-0.54**	**0.69**	**-0.62**	**-0.27**	0.65	0.57
	(2.81)	(3.16)	(4.87)	(2.87)		
20 UK	**-0.94**	**1.20**	**-0.93**	**0.28**	0.73	0.65
	(3.33)	(3.44)	(3.81)	(3.11)		
21 US	**-1.03**	**0.84**	**-0.58**	0.12	0.71	0.72
	(4.42)	(4.46)	(4.82)	(1.36)		

* Natural rate parameters not identified.

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