Asymmetric labour markets in a converging Europe: Do differences matter?

Ray Barrell and Karen Dury

National Institute of Economic and Social Research
2 Dean Trench Street
Smith Square
London
SW1P 3HE

Tel no: 0207 654 1909

Asymmetric economic structures across Europe may result in common shocks having asymmetric effects. In this paper we investigate whether the differences in the structure and dynamics that we observe in the European economies matter for policy design. In particular it is widely believed that labour market responses are different, with the structure of labour demand and the nature of the bargain over wages differing between countries. In addition the European economies move at different speeds in response to common shocks. In this paper we construct 3 different models of Europe, one where the labour market relationships are separately estimated and assumed to be different, one where the most statistically acceptable commonalties are imposed and one where common labour market relationships are imposed across all member countries. We use panel estimation techniques to test for the imposition of commonalties among countries. We find that it is possible to divide Europe into sub groups but it is not possible to have one model of European labour markets. We use stochastic simulation techniques on these different models of Europe and find that the preferred rule for the ECB is a combined nominal aggregate and inflation-targeting rule. We find that while this rule is dominant in all our models, the more inertia that is introduced into the labour markets, the more a nominal aggregate-targeting rule alone may be preferred. However, we conclude, that differences in the labour market transmission mechanisms across the European countries appear to have little influence on the setting of monetary policy for the ECB, although this depends on the relative importance of the different components in the welfare loss function.

Key Words: Labour markets, Asymmetries, Monetary policy rules, feedback rules, stochastic simulations, Macro-economic stabilisation.

1: Introduction

There is a consensus that the economies of Europe have significant differences in their transmission processes and our aim in this paper is to determine whether the differences in the structure and dynamics that we observe in the European wage bargaining system matters for policy design. The European Central Bank, ECB, has sole responsibility for setting the Euroland interest rate with the prime objective of maintaining price stability. The ECB will design its policy responses for the world it thinks exists and these responses will have different costs depending on the asymmetries across Europe. With differences remaining in the structure of the wage bargaining process across countries, a common monetary policy will have different impacts. If the ECB sets monetary policy for a world where it is assumed that all countries react in the same way, but actually is heterogeneous, then there could be significant costs involved that could be avoided if a reasonable description of the world were to be used. In EMU the monetary response is common to any shock however asymmetric, and the differential monetary shock absorbers have been removed. Given that one differential shock absorber has been removed more active fiscal policies could be implemented, but this may be constrained by the Maastricht Treaty and by the Stability Pact. Current policies may not be able to work as well in EMU as they did with floating or movable rates and it is important to evaluate the consequences of this. Policy settings that are the optimal choice for EMU may not be the optimal choice for individual countries. We will investigate how the dispersion cost changes as the structure of the European economy converges, and hence we will be able to discuss the policy problems facing the ECB Council. We aim to quantify these costs by examining 3 different models of the European wage bargain. Each of these represents a different strategy and a different conception of the way the Euro zone economy works. We can analyse policy problems when equations for wages in all countries are separately estimated and assumed to be different. We can also analysed policy when all countries are assumed to react identically and an intermediate case where we impose the most statistically acceptable commonalties.

The aim of this research is two fold. First we wish to analyse the wage determination process in the major European economies and examine the possibility of asymmetries in the bargaining process. We investigate the significance of any differences in the transmission mechanisms by examining the extent to which it is possible to group the countries together. We then ask how important potential differences may be for policy setting by the ECB. If significant differences remain between countries then a common monetary policy will result in asymmetric effects. We wish to investigate the importance of any asymmetries in the transmission of policy and this is achieved by undertaking stochastic simulation exercises on NiGEM.

In order to undertake the evaluation of these models they are embedded in the National Institute's Global Econometric Model, which is a coherent large-scale forward-looking model of the World economy. We first examine a set of deterministic shocks on each of the 3 models. This will give a clear comparison of the effects under a very specific shock. However, to investigate whether the structural differences across Europe matter it is also necessary to use stochastic simulation techniques so that the response to a sequence of random shocks can be evaluated. We examine the effects for individual member countries and EMU as a whole. We find that for the first model where the labour market structures are estimated separately that the preferred monetary policy rule for the ECB is a combined nominal and inflation targeting rule. We then investigate different rules for each of the 3 models and discuss the choice of rule in a converging Europe.

The paper is set out as follows: Section 1 describes the theoretical framework we adopt for analysing wage determination in the major European countries. Section 3 presents the empirical results for each model and discusses the process for estimating wage equations for the three different models of Europe. Section 4 sets out the second stage of the paper giving an outline of the policy environment used in the analysis, a brief summary of the techniques used to undertake stochastic simulations and an overview of NiGEM.[1] Section 5 presents the results from the stochastic simulations and examines the implications of a common monetary policy across Europe.

2: Labour markets across Europe

In order to assess the significance of the differences in transmission mechanisms across European labour markets we need an adequate description of the process of wage determination. The extensive literature on the analysis of labour markets within a bargaining framework is discussed and extended in Layard, Nickell, and Jackman (1991). In this paper we use their framework as set out in Barrell, Morgan and Pain (1995) and so consequently our theoretical discussion is brief. We assume that the bargain takes place in a right to manage framework, with employers determining employment after the bargain over wages has been struck. The outcome will depend on the objectives of the bargainers, their relative strengths and the environment in which they operate. We assume that in the long run the real wage is given by:

$$\ln\left(\frac{W}{P}\right) = a + \ln\left(\Pr od\right) - \lambda\, U^{e} \tag{1}$$

Where W is the nominal wage, P is a measure of producer prices, Prod is trend output per person hour and Ue is the long run sustainable level of unemployment. The equations were estimated in an Error Correction format with dynamics estimated round the long run. The general specification of the wage equations are given by:

$$\begin{aligned}\Delta\ln\left(\frac{W}{P}\right) = \alpha &+ \sum_{i=0}^{4}\beta_i \Delta\ln CED_{t-i} + \sum_{i=1}^{4}\gamma_i \Delta\ln\left(\frac{W}{P}\right)_{t-i} \\ &+ \left(1 - \sum_{0}^{4}\beta_i - \sum_{1}^{4}\gamma_i\right)\Delta\ln CED_{t+1} + \lambda\, U_{-1} \\ &+ \varepsilon\left[\ln\left(\frac{W}{P}\right) - \ln\left(\Pr od\right)\right]_{t-1}\end{aligned} \tag{2}$$

[1] Appendix A gives a fuller explanation of the stochastic simulations techniques and a more detailed description of the model.

where U is the level of unemployment and CED is the consumer price deflator. A unit long run coefficient on productivity was imposed and dynamic terms in wages, prices, and unemployment were included. Where possible, dynamic homogeneity was imposed in order that our models could be super neutral[2]. As the bargain is struck over the expected real wage our analysis has to take this into account. Employees form expectations about the development of future consumer prices and this affects their bargain with employers. Expectations of future inflation were extracted using instrumental variables on the future inflation[3].

3: Models of European wage bargaining

In this section we present the empirical results for 3 models of the European wage bargaining process. Model 1 is where the labour markets in each of the European countries have been estimated separately and are therefore assumed to be different. Model 2 has been estimated using panel techniques where the most statistically acceptable commonalties have been imposed across countries. Model 3 is where common labour market relationships have been imposed across all countries to yield a single representative equation for the European wage bargaining process. We present each model in turn and discuss the results.

3.1 Model 1

We have always presumed in our modelling that economic structures remain very different between European countries. The impact of a symmetric shock across countries, including interest rate changes, will differ in relation to the scale and speed with which the economy responds to that shock. A number of studies agree that significant differences remain in the transmission mechanisms across European countries Bayoumi and Eichengreen (1992) show that the response of member countries differs considerably to either demand or supply shocks. They show that there are significant differences in the size and adjustment speeds of EMU member countries. They along, with Ramaswamy and Sloek (1998), they show that there is a core group of countries, consisting of Austria, Germany, Belgium, Finland and the Netherlands, that have a faster adjustment of the economy to the steady state than in another group of countries including, France, Spain, Portugal and Italy. In the latter group the adjustment period is twice as large. Dornbusch et al (1998) also come to similar conclusions.

In this section we construct a model of European labour markets that characterise their 'true' underlying structure. There is continual structural change in labour markets and sustainable unemployment changes when policies change and so we construct models for each country that reflects the economies we are studying. Each labour market equation is estimated separately and then individually tested on NiGEM for its simulation properties. We aim to construct models of each country that ensures the simulation properties are a good representation of their labour market characteristics. Therefore the model selection criteria, comprises of two parts, estimating a reasonable wage equation for each country separately and then testing that equation on NiGEM. The wage equation included in the country model on NiGEM will be a good statistical description that ensures

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[2] This is to ensure that inflation doesn't affect the real side of the economy.

[3] Instruments include lagged consumer price inflation, producer price inflation and capacity utilisation.

the simulation properties of the model give a good representation of that particular labour market. The best statistical description may include a number of lagged terms in the dynamics but this may cause some chaotic behaviour in simulations. As a consequence, it may be necessary to allow some serial correlation in the equation so as to keep sensible simulation properties.

Table 1 presents the wage equations for the each individual country. The estimation procedure was to start with a general error correction model with a rich dynamic specification for each country, (as described in equation 2 above), and adopt the 'general to specific' approach to eliminate insignificant variables. The dynamic responses observed in the wage equations are the result of conscious construction of labour market institutions. All relationships were tested for structural change in the labour markets. For example we found strong evidence of a structural change in the role of unemployment in Germany at reunification in 1991, with the role of unemployment in moderating wages becoming significantly higher after unification. Evidence was found of a structural break in Italy in 1993 when the wage indexation formalised by the 'Scala Mobile' was abolished and a significant structural break was also found in the Spanish wage equation in 1987, after Spain joined the ERM.[4] Each equation was then tested for its simulation properties on NiGEM and the equations given in Table 1 were the final equations chosen. In general it was possible to impose dynamic homogeneity.

The dynamics and speed of adjustment differ among the European countries. We did not find a role for expectations in all countries and in some there is a clear mixture of backward and forward dynamics. We found a significant role for expected inflation in France, Spain, Italy, Ireland, Finland and the United Kingdom with the greatest role for expectations in the Italian wage bargain. However, not all countries display forward elements in the wage bargain, and we have not found them in Germany, the Netherlands or Austria. The likely reason for the absence of significant forward-looking behaviour in the German wage bargaining process, relates to the anti-inflationary successes of the Bundesbank. Germany and Austria experienced low levels of inflation with low variability and hence expectations probably varied very little. The long run coefficients on unemployment range from – 0.036 in Germany to –0.006 in Spain, suggesting that a 1% point rise in unemployment will reduce the level of real wages by between 0.6 and 3.6 percent in the long run. The impact on wages of a rise in unemployment is largest in Germany and the low coefficient in Spain, and indeed France and Ireland, suggests a greater degree of inertia in those countries, reflecting institutional rigidities. The speed of adjustment of real wages to deviations from the long run (given by ECORR) ranges from 0.06 in the Netherlands to 0.23 in Belgium. The average for the group is 0.12. Out of the four largest Euroland economies, only wages in France adjusts more slowly than the average. The UK's speed of adjustment is also lower than the average estimate.

[4] See Barrell and Genre (1999) for recent work on labour markets.

Table 1: Model 1 results - Country Specific Estimates

	GE	FR	SP	IT	NL	BG	PT	IR	FN	OE	UK		MEAN	MIN	MAX
CONS	-0.743 (4.7)	-0.448 (2.6)	-0.733 (2.7)	-0.692 (2.4)	-0.305 (9.3)	-1.151 (3.00)	-0.305 (9.3)	-0.433 (2.6)	-0.858 (3.7)	-0.305 (9.3)	-0.475 (3.0)		-0.451	-1.151	0.743
U(-1)	-0.006 (5.4)	-0.001 (2.7)	-0.001 (4.8)	-0.0037 (2.4)	0.004 (1.2)	-0.003 (2.9)	0.004 (1.2)	-0.001 (3.2)	-0.003 (5.0)	0.004 (1.2)	-0.0021 (2.8)		-0.001	-0.006	0.004
U					-0.005 (1.5)		-0.005 (1.5)			-0.005 (1.5)			-0.001	-0.005	-0.005
ΔP	0.624 (2.5)				0.534 (5.3)	0.444 (6.7)	0.534 (5.3)			0.534 (5.3)			0.243	0.444	0.624
ΔP(-1)		0.635 (3.4)			0.466 (4.7)	0.556 (-)	0.466 (4.7)			0.466 (4.7)			0.235	0.466	0.635
ΔP(+1)		0.364 (3.9)	0.348 (6.3)	0.604 (3.0)				0.339 (2.8)	0.583 (2.4)		0.394 (2.2)		0.239	0.339	0.604
DEP (-1)	-0.170 (4.00)							0.6076 (4.6)	-0.248 (2.8)				0.017	-0.248	0.608
DEP (-2)			0.652 (6.3)					0.053 (4.6)					0.064	0.053	0.652
ECORR	-0.167 (4.8)	-0.094 (2.7)	-0.155 (2.8)	-0.150 (2.4)	-0.061 (9.4)	-0.236 (2.9)	-0.061 (9.4)	-0.092 (2.8)	-0.176 (3.8)	-0.061 (9.4)	-0.102 (3.1)		-0.123	-0.236	-0.061

We next investigate whether it is possible to impose any commonalties across.

3.2 Model 2

For our Model 2 our aim was to impose as many commonalties across countries as possible, i.e. we wanted to construct a model for European wage bargaining that applied as widely as possible in a statistically defendable way. We adopt the common procedure for estimating panel models, the dynamic fixed effect approach, where the intercepts are allowed to differ across groups while all other parameters are constrained to be the same[5]. We started with a general unrestricted model of European wage bargaining, which included all dynamic terms encompassed in Model 1 above, but with dynamic homogeneity imposed and with each country equation retaining any structural breaks that had been identified in Model 1. We use a balanced data set from 1970Q1 to 1998Q4 and estimated the equations using the Seemingly Unrelated Regression Equation procedure (SURE). SURE allows the contemporaneous error covariances to be freely estimated which is a valid estimation procedure when N, (here the number of countries) is small relative to T, the number of observations. We first used a Wald test to see if we could impose common parameters across all countries. We found that imposing homogeneity across all parameters was an invalid restriction. (This is in fact Model 3 where we simply impose homogeneity, a more detailed discussion is given in the following section).

We then tested the possibility of imposing homogeneity across subgroups of countries. We estimated the equations in SURE for all countries without imposing constraints. We calculated the mean group estimator, MGE, and compared it to the restricted, or full panel estimate. In general the dynamics were slower in the panel, as can be seen in the table below. We were unable to impose the MGE, as shown in Table 3, and we looked for groups of countries with dynamics that were slower or faster than the MGE. The failure to impose the MGE is common in heterogeneous panels with disparate time responses. In such situations it is common for the speed of response in the panel to be lower than the MGE as here, indicating the biases calculated in Pesaran and Smith (1995).

Table 2 presents the results for the model where the most statistically acceptable commonalties are imposed across countries. We found that the European economies could be divided up into two subgroups. The first group consists of the core northern European countries, Germany, France, Netherlands and Austria. The second group consists of the Southern Europeans, Spain, Italy and Portugal. It was not statistically possible to include Belgium, Finland, Ireland or the UK in either group, nor was it possible to create a new subgroup containing any of these countries. We tried to pool Ireland and the UK together but this failed the Wald test. For these countries we kept the original equations for the stochastic simulation experiments.

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[5] We could be less restrictive and examine the Pool Mean Group estimators where only the long run coefficients are constrained and short run dynamics are allowed to differ freely in the estimation. However the aim of this paper is to construct a world where the European labour markets converge and then examine the implications of that for monetary policy. We do not aim to extensively compare different panel estimation techniques here, that is left for future research.

Table 2: Model 2 results
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	Group 1 : GE, FR, NL and OE					Group 2 : SP, IT and PT				MGE (model 3)
	FE	MGE	MIN	MAX		FE	MGE	MIN	MAX	
CONS	*	-0.060	-0.579	0.340		*	-0.134	-0.394	0.184	-0.297
U(-1)	-0.001 (4.5)	-0.001	-0.002	-0.001		-0.002 (3.7)	-0.003	-0.003	-0.002	-0.002
U	-	-	-	-			-	-	-	-
ΔP	0.402 (8.7)	0.290	0.139	0.431		0.326 (3.8)	-0.111	-0.782	0.321	0.210
ΔP(-1)	0.262 (5.3)	0.202	-0.036	0.580		0.255 (3.3)	0.103	-0.472	0.500	0.269
ΔP(+1)	0.336 (-)	0.508	0.282	0.789		0.480 (-)	0.966	0.172	1.421	0.465
DEP (-1)	-	-	-	-		0.092 (1.8)	0.085	0.078	0.090	-
DEP (-2)	-	-	-	-		-0.154 (2.8)	-0.043	-0.154	0.136	0.056
ECOR	-0.068 (4.43)	-0.080	-0.119	-0.063		-0.036 (2.1)	-0.036	-0.087	0.025	-0.065
Wald statistic	$\chi(11)$ =12.48 (0.328)					$\chi(11)$ =13.40 (0.268)				

Note: * country specific.

Apart from Italy, Group 1 consists of the largest economies in Euroland and makes up over 60% of Euroland output. It should be noted that the inclusion of Austria was only possible if we allowed idiosyncratic dynamics. However, only the coefficient on the second lag in the change in prices, ΔP(-1), was allowed to be estimated freely for this country. We also had to include an idiosyncratic dynamic term in Portugal in Group 2, this was the second lag of the dependant variable which was allowed to be estimated freely[6].

The main variable of interest is the error correction term[7], which indicates the length of time it takes for wages to adjust to deviations from the long run equilibrium. It gives the proportion of the deviation that is closed each period and the lower the estimate, the more time it takes to adjust to the disequilibrium and the more inertia there is in the economy. Group 2 shows more signs of inertia than the core Euroland economies where the estimate for the speed of adjustment is half that in Group 1. Model 2 has a lot more inertia than Model 1 where the countries were estimated freely. The panel estimate for the speed of adjustment for Group 1 is slower than the Mean Group Estimator is, however for Group 2 they are the same. In Group 1 we found the most statistically acceptable panel model did not include any endogenous dynamics whereas it was necessary to include them in Group 2. Forward looking behaviour can be retained in both cases but the core Europeans appear to be less forward looking than the southern Europeans, at least after structural breaks in the early 1990s.

[6] Therefore we have one less degrees of freedom than the table would indicate ((N-1) * no of constraints = 12) for each group.

[7] It is common to calculate indicators of nominal and real rigidities using the mean lag of the equation and the long run coefficient on unemployment (see Layard et al (1991). However in dynamically homogeneous equations the mean lag is zero. Other indicators must be used, but these are not in widespread used (Turner, Richardson and Rauffet (1996).

3.3 Model 3

Table 3 presents the results for the model where common labour market relationships are imposed across all countries and therefore statistical testing to determine the poolability of all countries is likely to fail. Our aim was to construct one model of the European wage bargaining process. Although the model gives reasonable estimates and significant t statistics for each variable, the assumption of homogeneity in across all countries was rejected. The aggregate equation has slow dynamics, as indicated by ECOR, and a significant role for unemployment.

Table 3: Model 3 results

	FE	MGE	MIN	MAX
CONS	*	-0.297	-0.977	0.377
U(-1)	-0.002 (8.8)	-0.002	-0.004	0.001
U	-	-	-	-
ΔP	0.384 (10.5)	0.210	-0.249	0.510
ΔP(-1)	0.295 (8.4)	0.269	0.022	0.476
ΔP(+1)	0.321 (-)	0.465	0.116	0.935
DEP (-1)	-	-	-	-
DEP (-2)	0.061 (2.5)	0.056	-0.186	0.301
ECOR	-0.046 (5.1)	-0.065	-0.198	0.059

Note: * country specific.

We followed standard procedures in time series modelling. We started with the full encompassing model for the wage bargaining process and deleted any insignificant variables. We found no role for the first lag in the dependent variable however we did find a role for a further lag in the dependant variable in the model. The speed of adjustment to deviations from the long run equilibrium again is slower in Model 3 than in Model 2 and considerably slower than Model 1. Testing to see if the restrictions implied by this model were valid unsurprisingly failed as the speed differences indicate heterogeneity. We also tested to see if it were possible to impose the error correction term to be the Mean Group Estimate while letting the dynamics to differ freely among countries. We found that it was not possible to accept the null hypothesis of homogeneity. This has not been commonly tested in models constructed using panel techniques and it is clearly possible that they are not valid descriptions of the world they attempt to analyse.

The aim of this paper is to take the three models of the European Wage bargaining process described above and embed them into the NiGEM framework. We then undertake stochastic simulation exercises to investigate the importance of the differences across European labour markets.

4: The model and policy response.

NiGEM is an estimated model, which uses a 'New-Keynesian' framework in that agents are presumed to be forward-looking but nominal rigidities slow the process of adjustment to external events. The theoretical structure and the relevant simulation properties of NiGEM are described in Barrell and

Sefton (1997) and NIESR (2000). The model has a full description of all the economies of the OECD, including South Korea[8]. Each economy has a supply side, a demand side, and a full set of asset accumulation relationships including a complete set of government sector, foreign sector and private sector financial accounts. Exchange rates follow the forward looking open arbitrage condition, and hence they can 'jump' when there is news, and long term interest rates are the forward convolution of expected future short rates and they can also 'jump' in the first period. Policy rules are important in 'closing the model' and we have them for fiscal and monetary policy. We assume budget deficits are kept within bounds in the longer term, and taxes rise to do this. Governments are assumed to slowly adjust tax rates to offset any changes in their deficit from its target trajectory, and hence they remain solvent in the simulation (See Barrell and Sefton (1997)). Further details are given in the annex.

The model is solved in a sequence of loops, utilising the sparse structure of forward links in time. A shock is applied, and the model is run over the full time period, and interest rates are allowed to be endogenous. A fall in demand will, for instance, cut interest rates. Forward looking agents know this, and we emulate this knowledge by running the model a second time, but calculating the long rate as the forward convolution of short rates in the previous run. The model is continually run forward and starts again, and this is repeated until a solution is found where rates of growth of expected variables are constant at the terminal date, and all equations are converged.

We concentrate on the use of various simple policy rules as opposed to complex optimal rules.[9] We compare four possible feedback rules for the interest rate that are nested within one general policy rule. We focus on a standard monetary policy rule, where the central bank targets some monetary or nominal aggregate, a combined nominal aggregate and inflation targeting rule, and a pure inflation targeting rule with different feedback coefficients. It appears from Duisenberg (1998), that the ECB has adopted a combination of money base targeting and inflation targeting and so in this paper we evaluate this rule against other rules nested within it.

In order to investigate the performance of these regimes we need to give an explicit form to the policy rule that is to be followed in this analysis. The three interest rate rules we investigate are encompassed by[10]:

$$r_t = \gamma_1 (Y_t - Y_t*) + \gamma_2 (\pi_t - \pi_t*) \qquad (1)$$

where r is the short term nominal interest rate, π = the annualised domestic inflation rate, Y is log of nominal output and an astrix denotes target variables. The policy rule that the ECB follows will depend

[8] China is also modelled separately and there are regional blocks for East Asia, Latin America, Africa , Miscellaneous Developing countries and Developing Europe.
[9] One of the main reasons for the widespread use of simple rules on large macro-economic models is that they are easy to understand and interpret. Advocates of simple policy rules argue that they are helpful in monitoring the performance of the authorities (see, for instance, Taylor (1985) and (1999)). A high degree of transparency gives them a considerable advantage.
[10] For further details on policy rules that are encompassed within a general framework see Barrell, Dury and Hurst (1999)

on the aggregates for the Euro zone and interest rates react to theses. The table below summarises the policy rules and the value of the feedback parameters used in this analysis.

Type of rule		Parameter values	
		γ1	γ2
NOM	Nominal GDP targeting rule	50	0
CR	Combined nominal GDP and inflation targeting rule	50	1
INFT	Inflation targeting rule	0	1

We use the terms, nominal GDP and monetary aggregate, as substitutes for each other, as a velocity de-trended monetary aggregate will move in line with nominal GDP in the medium term. We do not assume that the authorities wish to hit their target period by period so responses will be similar with either target. The rules used in this paper use the Consumer Price Index (CPI) inflation rate as a target.[11] The rules target the current rate of inflation and the current level of a nominal magnitude. It is sometimes argued that a measure of forecast inflation is more appropriate due to the lag in monetary policy affecting the economy[12]. However we believe it is likely that the ECB is actually reacting to what it perceives as current conditions, which are endogenous in our framework (and it is also the case that in a forward looking model current conditions are in part reflecting expectations of future outturns). For these reasons we concentrate on using current deviations from target in our rules.

5: Stochastic Simulations

The world is constantly faced with shocks; they can be large and infrequent or small and frequent. It is impossible to know where the next major surprise will come from. By repeatedly addressing the model with different sets of shocks it is possible to evaluate the range over which a variable may fall. Stochastic simulations require that shocks are taken at random from a particular distribution and repeatedly applied to the model. From this the moments of the solution of the endogenous variables can be calculated and variability investigated. Stochastic simulations can be either in respect to the error terms, coefficient estimates or both. In this paper we assume that the coefficient estimates are known with certainty and the stochastic shocks to the model are only applied to the error terms, much as in the rest of the economic literature.

We use the boot strap method where the shocks are generated by repeatedly drawing random errors from individual time periods for all equations from the matrix of single equation residuals (SER), as in Blake (1996). The shocks drawn will have the same contemporaneous distribution as the empirical distribution of the SER. In this way the historical correlation of the error terms are maintained across variables, but not through time. We have taken our model NiGEM, and calculated the historical shocks to all the structural equations for all 1000 estimated relationships. Our set of structural shocks have been applied repeatedly to our forecast baseline which runs 24 years into the future. Each application

[11] Issues arising from targeting the domestic inflation rate (where only inflation in the domestic component of the CPI, or GDP deflator) is targeted are dealt with in Svensson (2000).

[12] See Svensson 1997

produces a new future history that depends on the set of shocks applied, the 'counterfactual' baseline used and the period in which the shocks are applied. We have applied the shocks quarter by quarter over the period 1999 to 2003 running the model 'forward' to calculate the expectations that would be a reasonable response to the 'news' contained in the shocks. The model is solved for long enough to ensure the results are independent of the end points of the run. One replication in the set of stochastic simulations consists of shocking the model in the first quarter, solving forward for 18 years into the future. We then retain results from that quarter and repeat for each of the following 19 quarters we are shocking, using the output of the previous run as a new baseline. A set of replications involves doing this 200 times for each regime. Hence for the results reported in this paper we have a total of 4000 simulations per regime. We show in a previous paper that after approximately 100 stochastic simulations the variance of potential outcomes settles down[13], and hence a sound assessment of the variabilities of outcomes under different regimes can be made with 200 trial runs and that further simulations would not change the results noticeably.

In this paper we include shocks to exchange rates, as we think that departures from our structural exchange rate relationships are important sources of uncertainty in the world we describe. However, this is not standard practice in these exercises, but this in part reflects the difficulties that these exercises involve. We argue that any exchange rate uncertainty must be taken into account in the model and we do this by including shocks to the exchange rate in the stochastic simulations[14].

6: Asymmetries across Europe — deterministic simulation results

In this section we assess how the asymmetries across European labour markets can influence the effectiveness of monetary policy. We take the 3 models of European wage bargaining and embed them into the NiGEM. We then apply a specific deterministic shock, a loosening of monetary policy across Europe, to examine how the increasing degree of nominal inertia in the labour markets affects the different economies. The Charts below present the results for a loosening of monetary conditions in Euroland. In this section we concentrate on some of the largest member economies and the aggregate as a whole but for the stochastic simulation results we look at all countries. We simulated a 5% increase in the money supply under each of the models discussed above. The simulation results clearly show that as the degree of inertia increases in the European labour markets (moving from Model 1 to Model 3) the slower is the speed of response and the longer it takes to reach equilibrium.

The three charts below show the % difference from base for Euroland inflation, output and unemployment. Price responses are larger and faster in model 1 than in models 2 and 3 despite similar out-turns for unemployment. Increasing inertia in the labour markets in models 2 and 3 slow down price responses and creates more oscillations in the model and prolongs the adjustment back to the baseline path.

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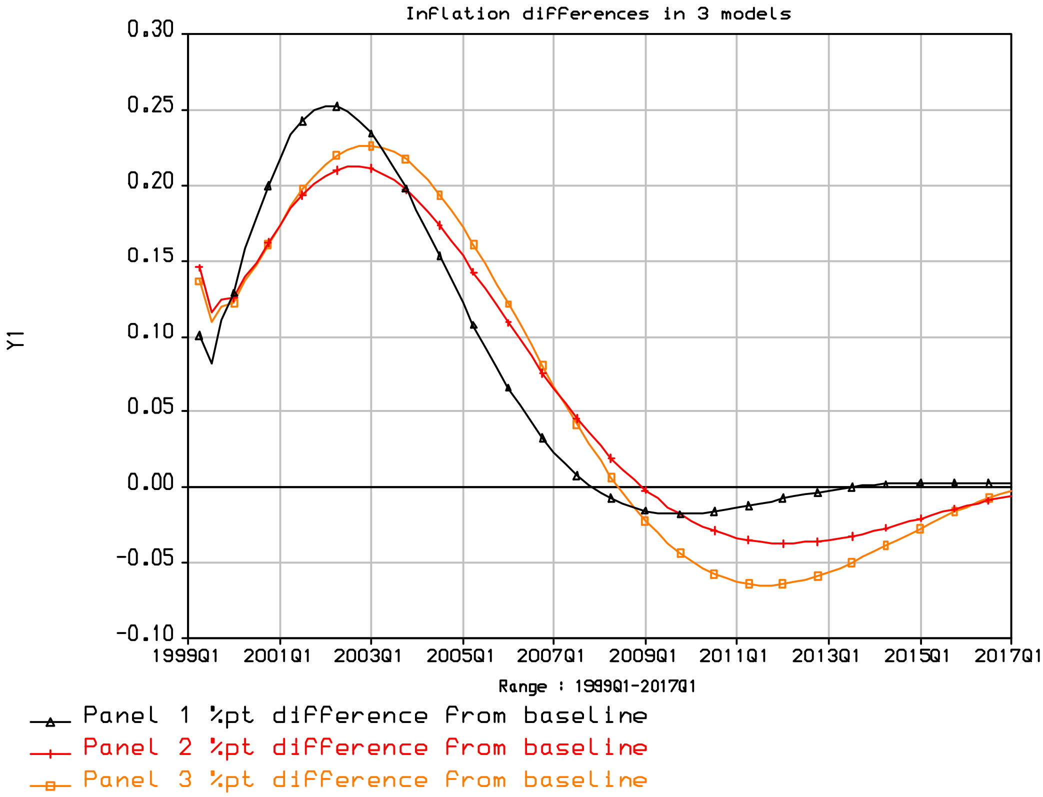
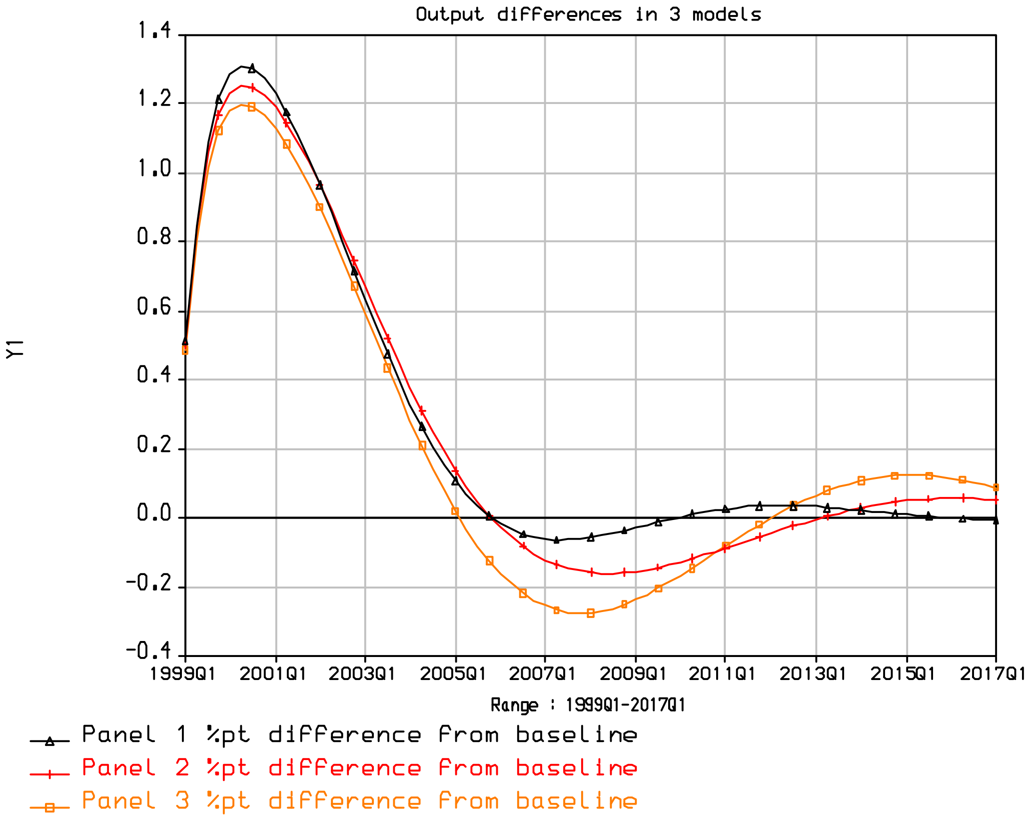
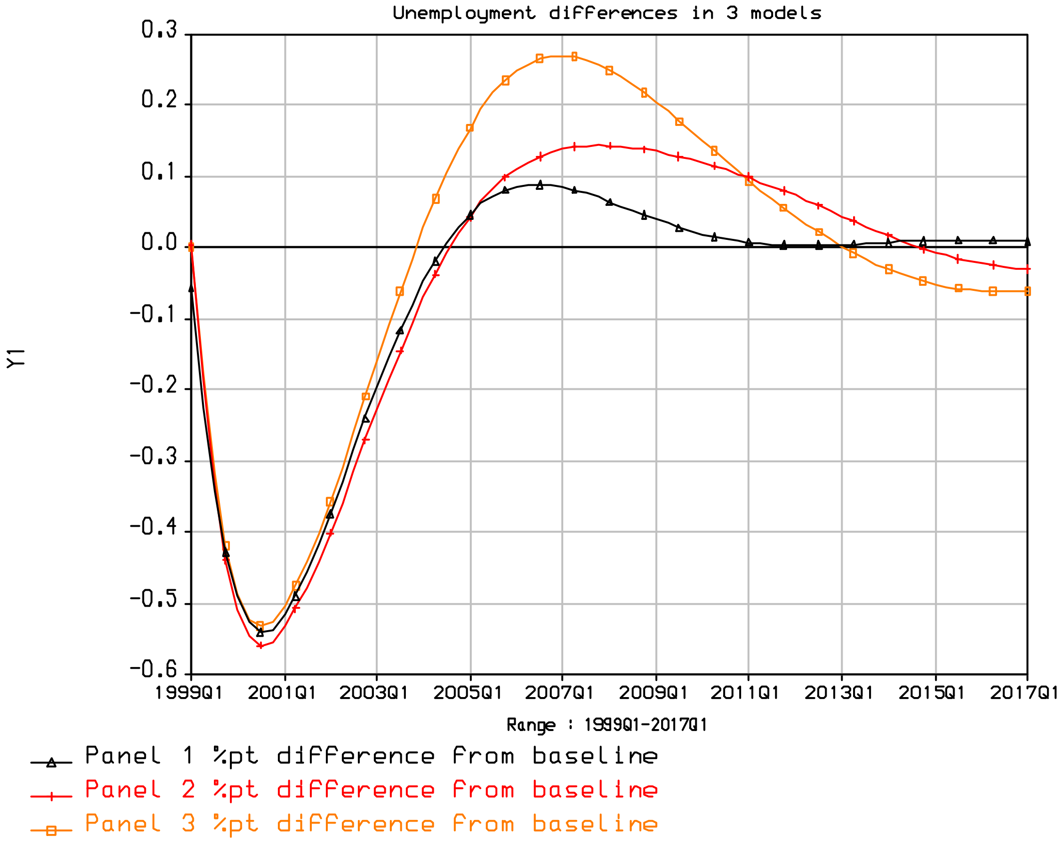
[13] See Barrell, Dury and Hurst (2000).

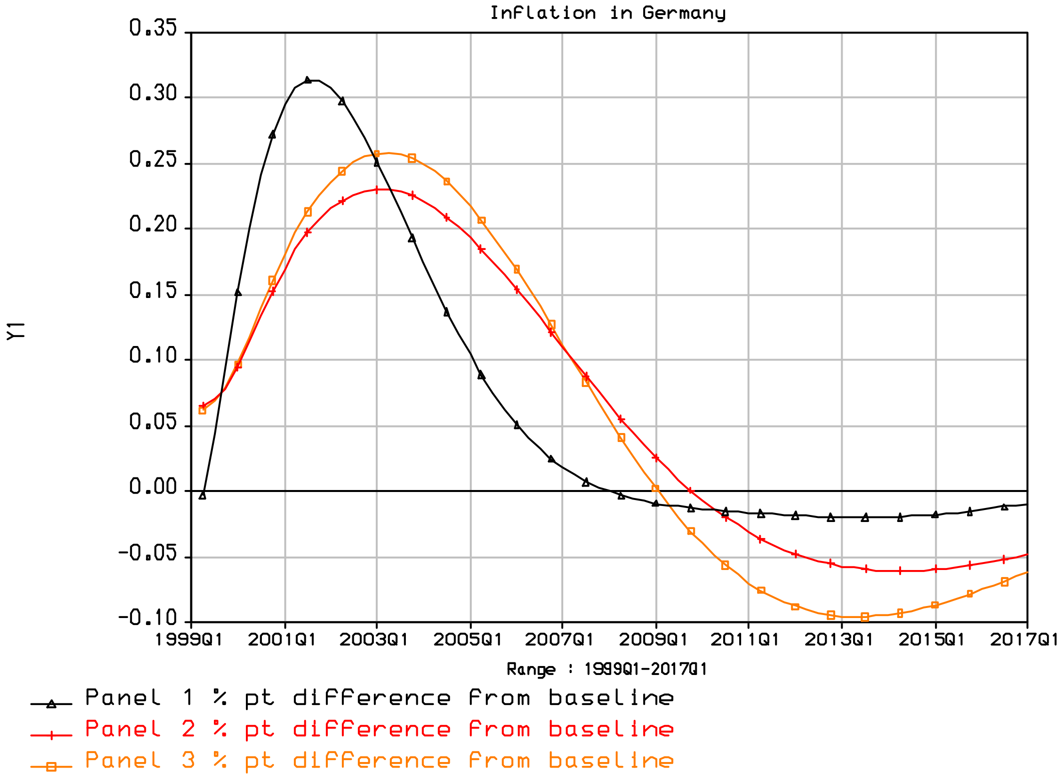
[14] For a more detailed discussion of the issues involved and the importance of shocking the exchange rate see Barrell, Dury and Pain (2000).

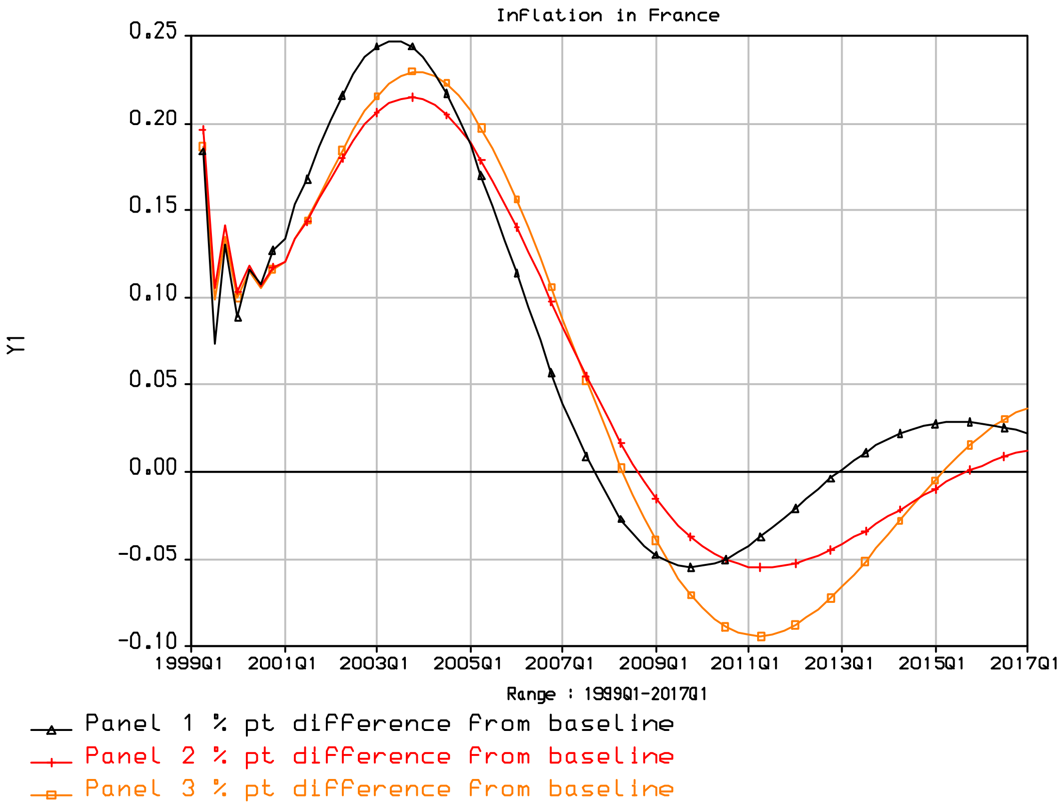

Inflation differences in 3 models
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
Y1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
2011Q1
2013Q1
2015Q1
2017Q1
Range : 1999Q1-2017Q1
Panel 1 %pt difference from baseline
Panel 2 %pt difference from baseline
Panel 3 %pt difference from baseline

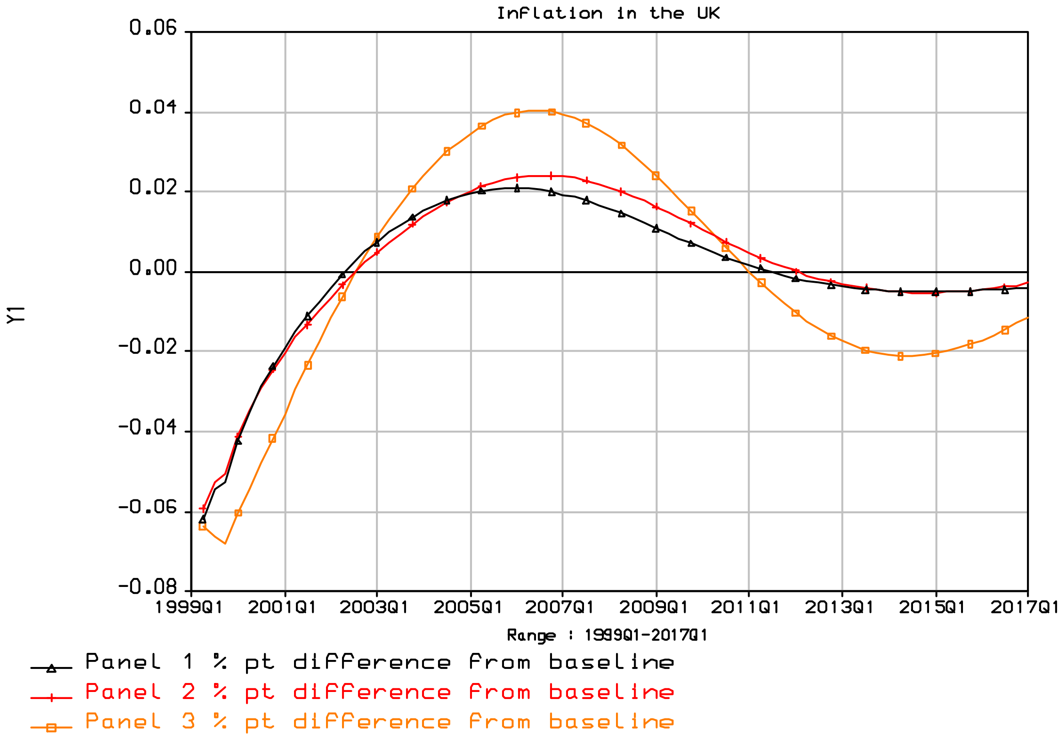

Output differences in 3 models
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Y1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
2011Q1
2013Q1
2015Q1
2017Q1
Range : 1999Q1-2017Q1
Panel 1 %pt difference from baseline
Panel 2 %pt difference from baseline
Panel 3 %pt difference from baseline



The following charts show some individual country results for inflation. The speed of adjustment coefficient in Germany is reduced from 0.16 in Model 1 to 0.07 in Model 2 and to 0.05 in Model 3. The degree of inertia is also increased in France in Model 2 and 3 but not by as much. The shock imposed is an expansionary shock to the Euroland economies and therefore the UK sees much of the effects through the shock to the exchange rate. In Model 2 for the UK the equation has remained the same as in Model 1 and so as the chart shows there is very little difference in the profile for UK inflation. However, in Model 3 the degree of inertia in the labour markets is increased as the speed of adjustment coefficient is halved, falling from 0.10 to 0.05.


Inflation in Germany
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
Y1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
2011Q1
2013Q1
2015Q1
2017Q1
Range : 1999Q1-2017Q1
Panel 1 % pt difference from baseline
Panel 2 % pt difference from baseline
Panel 3 % pt difference from baseline


Inflation in France
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
Y1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
2011Q1
2013Q1
2015Q1
2017Q1
Range : 1999Q1-2017Q1
Panel 1 % pt difference from baseline
Panel 2 % pt difference from baseline
Panel 3 % pt difference from baseline



7. The effectiveness of monetary policy — Stochastic simulation results

We concentrate here on the second moments; that is, we assess monetary policy in terms of how well it can minimise the variability of certain important economic variables, such as the price level, output, and inflation. The tables below present the results for each Euroland member country and the UK under the three policy rules. Following the analysis of Bryant et al (1993), the results from the stochastic simulations are reported as Root Mean Squared Deviations (RMSDs) from their target path[15]. This summary statistic gives a simple average of the deviations from target over the whole time period considered. The tables are given in an index form for an easy comparison to be made. The index value for the variability of results under the combined rule (CR) and the inflation targeting rule (INF) are given compared to the nominal GDP targeting rule (NOM). Where stochastic simulation results give a lower variability than under the Nominal GDP targeting rule, the box is shaded.

[15] $RMSD = \sqrt{(1/N)\sum_{t=1}^{N}\left\{(1/J)\sum_{j=1}^{J}\left[\frac{\left(x^{j}_{it} - x^{B}_{it}\right)}{x^{B}_{it}}\right]^2\right\}}$ where x^{j}_{it} is the value of variable *i* in period *t* from the *jth* trial, x^{B}_{it} is the value of the variable *i* on the base in period *t*, *J* is the number of trials taken. For variables such as interest rates and inflation rates, absolute deviations are measured.

Table 1: Variability of Output; Index value for CR and INF (Rule NOM = 100)

	Model 1			Model 2			Model 3	
	CR	INFT		CR	INFT		CR	INFT[16]
GE	98	104		100	108		98	120
FR	95	109		102	119		98	129
SP	99	110		99	122		99	132
IT	99	107		101	111		98	121
NL	99	102		100	105		99	118
BG	100	102		102	109		100	117
PT	99	102		103	107		100	118
IR	100	102		100	106		102	117
FN	94	108		103	114		99	123
OE	100	102		100	104		100	116
EL	98	105		101	111		99	121
UK	105	110		111	115		111	134

[16] Results for inflation targeting under Model 3 are provisional as time constraints prevented enough stochastic simulations to be

Table 2: Variability of Price level; Index value for CR and INF (Rule NOM = 100)

	Model 1			Model 2			Model 3	
	CR	INFT		CR	INFT		CR	INFT[17]
GE	82	119		85	115		95	122
FR	92	129		90	117		99	123
SP	94	107		90	111		94	110
IT	85	139		93	115		92	135
NL	87	112		94	113		92	115
BG	90	118		96	116		92	126
PT	93	107		101	110		99	138
IR	95	120		92	111		91	116
FN	94	134		102	133		100	135
OE	92	109		97	104		113	136
EL	81	131		85	124		93	134
UK	80	93		88	89		94	96

[17] Results for inflation targeting under Model 3 are provisional as time constraints prevented enough stochastic simulations to be

Table 3: Variability of Inflation; Index value for CR and INF (Rule NOM = 100)

	Model 1			Model 2			Model 3	
	CR	INFT		CR	INFT		CR	INFT[18]
GE	97	105		96	107		99	127
FR	95	111		101	114		101	123
SP	97	108		95	117		93	126
IT	100	109		100	104		97	120
NL	98	104		102	109		98	121
BG	99	100		102	105		99	116
PT	102	100		102	98		102	119
IR	96	104		98	109		95	106
FN	100	109		103	109		101	122
OE	100	102		102	104		103	120
EL	93	111		97	118		95	133
UK	98	98		99	95		102	120

[18] Results for inflation targeting under Model 3 are provisional as time constraints prevented enough stochastic simulations to be

Summary tables are given below for variabilities of Euroland as a whole.

Table 4: Variability of Output; Index value for CR and INF (Rule NOM = 100)

Model	NOM	CR	INF
1	100	98	105
2	100	101	111
3	100	99	121

Table 5: Variability of Price level; Index value for CR and INF (Rule NOM = 100)

Model	NOM	CR	INF
1	100	81	131
2	100	85	124
3	100	93	134

Table 6: Variability of Inflation; Index value for CR and INF (Rule NOM = 100)

Model	NOM	CR	INF
1	100	93	111
2	100	97	118
3	100	95	133

The tables show that the variability of output, price level and inflation in the Euro area as a whole is reduced under the combined nominal aggregate and inflation-targeting rule, CR. However, as we introduce more inertia into the European labour markets we find that the disparity between the Nominal aggregate rule, NOM, and the Combined rule, CR, falls. This is particularly noticeable in the variability of the price level where the ratio of RMSDs rises from 81 to 93. The evidence suggests that introducing further inertia in the labour markets may result in the nominal targeting rule giving lower variability the for Euroland aggregates than the combined rule. The tables also show that the performance of the Euro zone is also worsened as we introduce progressively more inertia in the labour markets. This is in line with more recent theoretical literature, which argues that inflation targeting can have destabilising effects. Clarida, Gali and Gertler (1999) and Svensson and Woodford (1999) have argued that in a simple New-Keynesian model with inflation targeting the optimal policy results in a stationary price level process. Svensson (1999) also shows that if output is sufficiently persistent then price level targeting may reduce both output and inflation variability. The nature of the supply relationship is important here as Kiley (1998) shows. With a Phillips curve relationship in a new-Keynesian framework it is possible that output variability might be higher under price level targeting than under inflation targeting. However, this model changes if it has Taylor style contracting, where wages or prices depend on past experience and expectations of the future, added to it. It is then possible that one can design a policy rule that weights output in such a way that inflation is more stable under price level targeting, as Vestin (1999) shows. We show here that as more inertia is introduced into these labour markets the performance of the economy under inflation targeting is worsened. The results for the UK, the more open economy, also show the same pattern as more inertia is introduced into the UK labour market the output, inflation and the price level become more volatile and this is particularly the case when inflation targeting is used. The more inertial the labour market the better is a nominal rule at stabilising the economy.

8: Choice of Rule

It is likely that policy makers will not focus solely on the variability of one variable and will be concerned with the variability of both output and inflation rates and so both will appear in their loss functions. They may also believe that other non-price variables are an indication of economic welfare. Large frequent fluctuations in the interest rate may be regarded as imposing costs on the economy and so may be included in the loss function and this may change the conclusions about the relative performance of the policy rules. However, for illustration we concentrate on the output, inflation and the price level. The outcome of any loss function will depend on the relative weights on its arguments. Where the loss function has more than one argument, then equal weight is placed on each. We compare the results for each of the models discussed above.

Table 7: Preferred rule (least preferred rule) for some illustrative welfare loss functions.

		Preferred Rule (least preferred rule)		
		Model 1	Model 2	Model 3
Euroland				
Output		2 (3)	1 (3)	2 (3)
Inflation		2 (3)	2 (3)	2 (3)
Price level		2 (3)	2 (3)	2 (3)
Output and Price level		2 (3)	2 (3)	2 (3)
Output and inflation		2 (3)	2 (3)	2 (3)
Output, inflation and Price level		2 (3)	2 (3)	2 (3)
UK				
Output		1 (3)	1 (3)	1 (3)
Inflation		3 (1)	3 (1)	1 (3)
Price level		2 (1)	2 (1)	2 (1)
Output and Price level		1 (3)	1 (2)	1 (3)
Output and inflation		2 (3)	1 (3)	1 (3)
Output, inflation and Price level		2 (3)	3 (2)	1 (3)

The table shows that for each different model we have examined that if we give equal weight to each element in the loss function the ECB will almost always choose the combined nominal aggregate, and inflation targeting rule and will never choose to implement an inflation targeting rule. There is only one case where the ECB may prefer the nominal aggregate rule, NOM, over the Combined rule, CR, and that is in the second model where output variability is higher under the combined rule. If the ECB put a weight of over 55% on output in its welfare loss function then the nominal rule would be preferred to the combined rule if the loss function included just output and the price level variability. If the loss function was a combination of just output and inflation and did not include the variability of the price level then the nominal rule would be preferred if the weight on output were over 50%. If the loss function was a combination of all three variables and output took a 50% weight with the price level and inflation taking equally 25%, then ECB would clearly choose the nominal rule and not the combined rule. Therefore setting policy in a world where the decision-makers rely on an estimate with more homogeneity in European labour markets than actually exists could induce the ECB to use the wrong rule.

The results for the UK are more mixed. In terms of inflation as more inertia is introduced into the labour markets then the Bank of England would change its preferred rule to a nominal aggregate rule. If the sole concern was the price level then the preferred rule for the UK economy would always be the combined rule where the price level is included in the targeting rule however, the choice become more marginal as you move to model 3. This indicates that any further inertia in the labour markets would result in changing the preferred rule to a purely nominal aggregate rule. In terms of output the preferred rule is the nominal aggregate rule and as we move to model 3 this rule becomes progressively more dominant.

9: Conclusion

We have estimated 3 different models for European Labour markets, one where the labour market relationships are separately estimated and assumed to be different, one where the most statistically acceptable commonalties are imposed and one where common labour market relationships are imposed across all member countries. We use panel estimation techniques to test for the imposition of commonalties among countries and found that we can divide the European economies into a core group, consisting of Germany, Netherlands, Austria and France, and another periphery group consisting of the southern economies Spain, Italy and Portugal. However, it is not statistically possible to group all countries together. We found that the panel estimates progressively introduce more inertia into the European wage bargaining process as we increased the common elements within Europe. The most extreme versions of a common labour market for Europe could not be justified on the grounds of statistical tests although it gave plausible and significant results. We took these models and embedded them into NiGEM. We then used stochastic simulations to determine how much differences in the transmission process across the European countries matters for monetary policy design. The choice of loss function weights and the description of the European labour market both matter in the choice of a preferred rule. We find that there is a sound case for designing a framework that has the level of a nominal variable, and preferably the price level as an explicit argument with sufficient weight to ensure that inflation variability is reduced. There was also some case for including a reaction to short term inflation. We can conclude that differences in the labour market transmission mechanisms across the European countries appear to have little immediate relevance to the choice of framework for the setting of monetary policy for the ECB. If the ECB designs its interest rate policy according to a world it thinks exists (e.g. where all countries have the same labour market transmission mechanisms), but where the economies actually do show different responses it would still probably chose the same rule. However, our conclusions are different for a small open economy such as the UK. The world that is thought to exist can have a significant bearing on the type of policy rule implemented and there could be large costs associated with designing policy in a world that is different to reality

Annex A: Modelling the World economy

Any model we build should be a description of the world we live in, rather than a description of the currently fashionable economic theory. However, economic theory tells us a lot about the world, and gives us strong indications about the structure of our model. It is useful, for instance to consider both stocks and flows.

- In a world model we need a description of trade in goods and services, a description of the structure of foreign assets and liabilities, and links between these and the rest of the model. The current account flows onto the asset stock, and cumulated current accounts should affect future income flows.
- Each country that we wish to study needs a description of its domestic economy. This can be broken up into sectors, and the minimum would cover the government, the labour market, consumption behaviour, the supply side of the economy and financial markets.
- These elements need to be integrated into a model of longer-term development. We have tended to use an extended Solow growth model where output grows because the quantity of labour and capital increase and because there is technical change.

In each area we try to look at the role of relative prices and also at the accumulation of assets. It is important to avoid 'black holes' in the model where income is received by one party, but where there is no counterparty paying the income (or the reverse for payments). This is particularly problematic for a world model as world exports do not equal world imports, and we have to ensure that the discrepancy does not grow without bound in the forecast or in a policy analysis.

The model uses a 'New-Keynesian' framework, in that agents are presumed to be forward-looking but nominal rigidities slow the process of adjustment to external events. The theoretical structure and the relevant simulation properties of NiGEM are described in greater detail in Barrell and Sefton (1997) and NIESR (1998).

The model is large, but with a common (estimated and calibrated) underlying structure across all economies. It has complete demand and supply sides, and there is an extensive forward-looking monetary and financial sector. The model contains a wealth equilibrium for the private sector. Governments are constrained to be solvent, and hence also have an asset equilibrium. These two constraints tie down the net asset holdings of the external sector. Thus the long run structure of the model embeds equilibrium capital flows that depend upon these saving and investment balances as well as on the structure of the world economy. All countries in the OECD, including South Korea, are modeled separately, as is China. There are regional blocks for East Asia, Latin America, Africa, OPEC, Miscellaneous Developing countries, and Developing Europe. The major economies are each represented by 60-90 equation models with around 30 key behavioural relationships.

Model Structure

In this section we give a brief description of each sector – trade, government, consumption, investment, the labour market, and technical progress along with some discussion of financial markets and policy reactions. In each case we want to look at the important feedbacks that stabilise the model in the long run

Trade. We look for demand and relative competitiveness effects, and the latter are important feedbacks in the model. There are a variety of competitiveness measures we can construct. For exports we assume that exporters compete against other people who export to the same market (RPX), and demand is given by the imports in the markets to which the country has previously exported (S)

$$\Delta X = \lambda[X(-1) - S(-1) - b*RPX] + c1*\Delta X(-1) + c2*\Delta S + \quad + \text{ error}$$

and imports depend upon import prices relative to domestic prices (RPM) and on demand (TFE)

$$\Delta M = \lambda[M(-1) - TFE(-1) - b*RPM] + c1*\Delta M(-1) + c2*\Delta TFE + \quad + \text{ error}$$

As exports depend on imports, they will rise together in the model. We have a similar pattern for services trade, but relative price elasticities are higher. In all cases competitiveness depends in part on domestic prices or costs, and a rise in domestic prices not matched either by a change in the exchange rate or foreign prices will mean net exports will fall, and hence output will fall relative to where it would have been. The current account deficit cumulates onto foreign debt, and this forms part of private sector wealth, and hence current deficits are a slowly acting stabilising feedback.

Government. It is important to have sketch models of direct and indirect taxes, and of government spending. We separately identify transfers to individuals and government interest payments. We also have to consider the financing of the government deficit (BUD), and we allow either money (M) or bond finance (DEBT).

$$BUD = \Delta M + \Delta DEBT$$

The debt stock affects interest payments and forms part of private sector wealth. The model explicitly recognises the link between monetary and fiscal policy through their effects on the government budget constraint, and it is wrong to analyse these policies in isolation.

Consumption This reflects the major component of demand, and hence has the most important feedbacks in it. We assume that consumers consider their current income (RPDI income including non-labour income net of taxes) and their real financial wealth (RNW), and that interest rates have a potential effect.

$$\Delta C = \lambda[C(-1) - a*RPDI(-1) - (1-a)*RNW(-1)] + \Delta C(-1) + \quad + \text{ error}$$

This equation is one of the most important we can consider in forecasting. We assume that wealth is affected by financial markets through equity and bond prices, and hence if these markets ‘expect’ something in the future then it will be reflected in prices. News that changes expectations will cause wealth to be revalued, and hence will affect behaviour now. Consumers use the financial markets as agents to assess the future. The rate of spending from wealth (wealth effects) need to be larger than the real interests rate in order for the model to stabilise. Wealth effects are an important but slow acting feedback. They link financial markets, the current account and government to the real economy. A good deal of care needs to be taken on modeling the acquisition of assets and the effects of revaluations.

Investment For forecasting purposes it is adequate to model investment with a simple accelerator model, with some role for the interest rate. However, if we are interested in growth and the long run structure of the model, we have to relate investment to the capital stock, and hence we have to model it as a factor demand, relate it to the demand for labour and link to capacity utilisation. The demand for capital has to depend upon the user cost, which depends on real interest rates with forward looking expectations of inflation. We use a Constant Elasticity of Substitution production function with an estimated elasticity of substitution of around a half.

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-v/\rho}$$

Here v denotes returns to scale, γ and s are production function scale parameters, and the elasticity of substitution, σ, is given by $1/(1+\rho)$. If $\sigma = 1$ ($\rho = 0$), the production is Cobb Douglas. Variables K and L denote the net capital stock and labour input measured in terms of employee hours. The production function allows for the possibility of labour augmenting technical progress. The parameters of the production function vary across countries and w, c and p denote respectively labour costs per head, nominal user costs of capital and the price of value added (at factor cost) and β denotes the mark-up. Imposing long-run constant returns to scale (v=1) we obtain log-linear factor demand equations of the form:

$$Ln(L) = \left[\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p)$$

$$Ln(K) = \left[\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - \sigma \ln(c/p)$$

We estimate these as error corrections around the long run, but there is a lot of calibration. Capacity utilisation affects price setting and depends on actual as compared to desired capital, and once again this is one of the central feedbacks in the model. If output is above capacity prices rise more rapidly than their determinants (foreign prices, costs, expectations) would suggest, and the reverse is the case if the economy is below capacity. If prices fall relative to baseline because the economy is below capacity then real financial wealth rises, and competitiveness improves, and both help raise capacity utilisation through higher domestic demand and exports. These effects stabilise the economy slowly.

The Labour Market contains another important feedback, but again this is difficult to model outside the core OECD countries. We have a labour demand curve, and we assume that employers have a right to manage, and hence the bargain in the labour market is over the real wage. In the long run wages rise in line with productivity all else equal. Other factors matter, for instance if unions become stronger real wages rise and employment falls. Given the determinants of the trajectory for real wages, if unemployment rises then real wages fall relative to trend, and conversely. Hence unemployment acts as an important feedback. However, this only works if labour supply is inelastic or fixed. It is inappropriate as a model where there are large reserves of labour and other measures of labour market excess supply have to be used. In our modeling we allow expectations of the future to affect the dynamic path of the bargain, at least where we can find evidence that this matters.

There is continual structural change in labour markets and sustainable unemployment changes when policies change, and we have to continually update our model so that it reflects the economies we are studying, rather than being just a simple description of past data. Both the determinants of equilibrium and the dynamics of adjustment change, and adjustment, especially in Europe is slow.

We assume that labour markets embody rational expectations, at least where we have evidence that bargainers use forward expectations of future inflation (Anderton and Barrell, 1995). However, not all countries display forward elements in the wage bargain, and we have not found them in Germany, the Netherlands or Austria. In certain circumstances we assume that wage bargainers do not use model consistent expectations, but rather look at a simple time series predictor for next periods inflation.

Financial markets affect asset prices. For most purposes we assume that exchange rate markets are forward looking, and exchange rates 'jump' when there is news. The size of jumps depends on the effects on interest rates that are anticipated for the future, and hence policy rules affect financial markets. We assume that bond and equity markets are also forward looking, and long-term interest rates reflect short rates that are expected in the future. In forecasts we normally 'read' interest rates for the future from long-term rates, and set paths for exchange rates in line with interest differentials. Occasionally we claim to know more than the market.

The forward-looking nature of these markets is central to model properties, and especially in shocks such as that in East Asia and Latin America. The model is solved in a sequence of loops, utilising the sparse structure of forward links in time. A shock is applied, and the model is run over the full time period, and interest rates are allowed to be endogenous. A fall in demand will, for instance, cut interest rates. Forward looking agents know this, and we emulate this knowledge by running the model a second time, but calculating the long rate as the forward convolution of short rates in the previous run. The model is continually run forward and starts again, and this is repeated until a solution is found where rates of growth of expected variables are constant at the terminal date, and all equations are converged. In particular, long-term interest rates are forward convolutions, and this period's exchange rate depends on that next period adjusted through the arbitrage condition but short term interest rate differentials. This algorithm is a version of Fair-Taylor set up in the way Hall (1986) recommends.

Policy rules are important in 'closing the model' and we have them for fiscal and monetary policy. We assume budget deficits are kept within bounds in the longer term, and taxes rise to do this. This simple feedback rule is important in ensuring the long run stability of the model. Indeed, as Blanchard, 1986, shows, without a solvency rule (or a no Ponzi games assumption) there is no solution to a forward-looking model. We can describe the simple fiscal rule as

$$Tax_t = Tax_{t-1} + \phi\ [GBRT – GBR]$$

Where Tax is the direct tax rate, GBR and GBRT are the government surplus target and actual surplus, and ϕ is the feedback parameter designed to remove an excess deficit in less that five years.

We also assume that the monetary authorities target something (we allow a large variety of rules) that stabilise the price level or the inflation rate in the long term. The speed of response of the authorities affects the properties of the model. In our forward-looking world the expectation that interest rates would be lower would mean that the exchange rate would decline now. This would improve competitiveness in the short run and would raise demand. This would eventually increase prices as compared to where they would have been. If the target for the money stock were raised by 10 percent the exchange rate would have to fall by 10 percent or so in the first period to put the economy on the path to equilibrium. This sort of policy analysis is easy to undertake, and involves one simple change. We can also change either the target rate of growth of the nominal aggregate or the rate of inflation, and analyse the effects of the dynamics of inflation on the model.

Annex B: Stochastic simulations

Within the framework of stochastic simulations, different sets of shocks are repeatedly applied to the model. These shocks are taken at random from a particular distribution. By repeatedly simulating the model in this way the moments of the solution of the endogenous variables can be calculated and the uncertainty of the model investigated. Stochastic simulation can be either in respect to the error terms, coefficient estimates or both. In this paper we assume that the coefficient estimates are known with certainty and the stochastic shocks to the model are only applied to the error terms.

The method used is known as the boot strap method where the shocks are generated by repeatedly drawing random errors from the matrix of single equation residuals (SER). The shocks drawn will have the same distribution as the empirical distribution of the SER, which is assumed to be normally distributed, $N(0,\sigma^2)$. There are a number of other methods for drawing the shocks which rely on generating pseudo-random shocks which are consistent with the historical residuals or specifying the variance-covariance matrix (see Ireland and Westaway 1990 for a description).

One of the main techniques used for generating shocks is the McCarthy algorithm (1972). This approach uses the formula to generate a vector of shocks:

$$S = T^{0.5}\, rU$$

where S is the vector of random shocks, r is the 1 x T vector of random numbers with distribution $N(0,1)$ and U is the T x M matrix of disturbances from T observations and M structural equations. The properties of S tend to the true structural errors as T tends to infinity, giving an asymptotic estimate of the true covariance matrix.

The method we are using takes the actual historical residuals but are picked at random from the SER matrix. In this way computational requirements before the model is solved are reduced considerably.

There are X stochastic equations in NIGEM, x post recursive and x identity equations. The period taken to calculate the single equation residuals is 1993Q1 to 1997Q4. Each stochastic equation is shocked in the first period with a random drawing of its errors over this historical period and the model is then solved forward to calculate expectations. This can be thought of as being equivalent to a single deterministic simulation.

A second random drawing of error terms is then made and applied to each stochastic equation in the following period, and again the model is solved forward. This is repeated for all time periods being stochastically simulated and is known as a ‘trial’. Each trial will consist of T *(time period for which we are stochastically simulating)* draws of X *(number of stochastic equations)* values. This can be done as many times as desired and each trial will yield an estimate of the endogenous variables for each time period. This can be done as many times as desired and each trial will yield an estimate of the endogenous variables for each time period. It is important to solve the model far enough into the future so that the results in a trial solution period are not affected by the terminal date. In this paper we stochastically shock the model over the first 5 years of our forecast baseline but each time a shock is applied, the model is solved forward to 2017q1. For a 5 year solution period, each trial consists of 20 simulations and we undertook 200 stochastic trials for each rule. Therefore the total number of simulations undertaken in this paper was 4000 (20 X 200)

After running the stochastic simulations the moments can be calculated. The expected value of each endogenous variable, at time *t*, is obtained by dividing the sum of all trial estimates at time *t* by the number of trials:

$$\tilde{\bar{y}}_{it} = \frac{1}{J}\sum_{j=1}^{J} \hat{y}^{j}{}_{it}$$

where $\tilde{\bar{y}}^{j}{}_{it}$ is the value of the *jth* trial of variable *i* in period *t*; *J* is the number of trials taken.

Given *J* trials, the stochastic simulation estimate of the variance for level variables such as output and consumption for period *t* is calculated as:

$$\tilde{s}^{2}{}_{it} = \frac{1}{J}\sum_{j=1}^{J}\left[\frac{\left(y^{j}{}_{it} - y^{B}{}_{it}\right)}{y^{B}{}_{it}}\right]^{2}$$

Where $\tilde{s}^{2}{}_{it}$ denotes the estimated variance of the variable *i* in period *t*, $y^{j}{}_{it}$ is the value of the *jth* trial of variable *i* in period *t*, $y^{B}{}_{it}$ is the value of variable *i* on the base in period *t*, and *J* is the number of trials taken. This will give a time series of estimated variances for each variable. We then take a simple average of this series over *N* time periods and take the square root to give a simple summary statistic to help assess the performance of the policy rules over the whole time period. The summary statistic given in the following tables are the *RMS%D*s, i.e.

$$RMS\%D(y_i) = \sqrt{\left(\frac{1}{N}\right)\sum_{t=1}^{N}\left\{\frac{1}{J}\sum_{j=1}^{J}\left[\frac{\left(y^{j}{}_{it} - y^{B}{}_{it}\right)}{y^{B}{}_{it}}\right]^{2}\right\}}$$

For variables such as interest rates and the inflation rate, absolute deviations are measured in percentage points, i.e. the RMSD for the interest rate, *r*, would be:

$$RMSD(r) = \sqrt{\left(\frac{1}{N}\right)\sum_{t=1}^{N}\left\{\frac{1}{J}\sum_{j=1}^{J}\left(r^{j}{}_{t} - r^{B}{}_{t}\right)^{2}\right\}} \qquad (5)$$

where $r^{j}{}_{t}$ is the value of the interest rate for trial *j* in period *t* and rB_t is the value of the interest rate on the base in period *t*.

Bibliography

Anderton, R., and Barrell, R. (1995), “The ERM and Structural Change in European Labour Markets: A study of 10 countries”, *Weltwirtschaftliches Archiv*, Band 131, Heft 1.

Barrell, R. and Genre, V. (1999), “Employment Strategies for Europe: Lessons from Denmark and the Netherlands”, *National Institute Economic Review*, April.

Barrell, R. and Sefton, J. (1997). “Fiscal Policy and the Maastricht Solvency Criteria”, *The Manchester School*, June, Vol 65, No. 3.

Barrell, R., Dury, K. and Hurst, I. (1999), “An Encompassing Framework for Evaluating Simple Monetary Policy Rules” *National Institute Discussion Paper* no. 156.

Barrell, R., Dury, K. and Hurst, I. (2000), “International Monetary Policy Coordination: An Evaluation of Cooperative Strategies using a Large Econometric model’, *National Institute Discussion paper*, No. 160.

Barrell, R., Dury, K. and Pain, N. (2000), “Decomposing Forecast Uncertainty” *National Institute Discussion Paper*, forthcoming.

Bayoumi, T. and Eichengreen, B. (1992), “Shocking aspects of European Monetary Unification”, CEPR discussion paper, No. 643, May.

Blake, A. (1996), “Forecast Error Bounds by Stochastic Simulations”, *National Institute Economic Review*, May.

Bryant, R.C., Hooper, P. and Mann, C.L. (1993), *Evaluating Policy Regimes: New Research in Empirical Macroeconomics*, Washington, Brookings.

Carida, R., Gali, J. and Gertler, M. (1999), “the science of monetary policy: A new-Keynesian perspective”, Journal of Economic Literature, XXXVII (December), pp 1661-1707.

Clements, M. P., and Hendry, D. F., (1998), *Forecasting Economic Time Series*, Cambridge University Press.

Dornbusch, R., Favero, C. and Giavazzi, F. (1998), “Immediate challenges for the European Central Bank”, Economic Policy, 26, April.

Duisenberg, W. (1998), “A Stability Oriented Monetary Policy for the ESCB.” European Central Bank, Franfurt.

King, M. (1999), ‘Challenges for Monetary Policy: new and old’ At symposium on ‘New Challenges for Monetary Policy’ Federal Reserve bank of Kansas, Jackson Hole, August 1999.

Layard, R., Nickell, S., and Jackman, R. (1991), “Unemployment: Macroeconomic Performance and the Labour Market”, Oxford University Press.

NIESR (2000), “World Model Manuals” NIESR, London, Mimeo

Pesaran, MH. and Smith, R. (1995), “Estimation of long-run relationships from dynamic heterogeneous panels”, Journal of Econometrics Vol 68., No. 1, pp 79-114.

Ramaswamy, R. and Sloek, T. (1998), “ The real effects of monetary policy in the European Union: What are the differences? ”, IMF Staff Working Papers, forthcoming.

Svensson, L. (1999), “Price Level Targeting or Inflation Targeting: a Free Lunch”, Journal of Money, Credit and Banking, Vol 31., No.3., August.

Svensson, L. (2000), “Open-Economy Inflation Targeting", Journal of International Economics, Vol 50., No.1., February.

Taylor, J. B. (1999), “The Robustness and Efficiency of Monetary Policy Rules as Guidelines for Interest Rate setting at the European Central Bank”, in *Monetary Policy Rules*, National Bureau of Economic Research, University of Chicago Press.

Turner, D., Richardson, P. and Rauffet, S. (1996), “modelling the Supply side of the seven major economies”, OECD Working paper, No. 167, August.

Vestin, D., (1999) ‘Price Level Targeting versus Inflation Targeting in a Forward Looking Model’, mimeo.