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Testing for a Common OECD Phillips Curve

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ABSTRACT/RÉSUMÉ

This paper reports estimates of a reduced form relationship explaining inflation in terms of the output gap and import price inflation for most OECD countries. Results are reported both for single equation estimation on a country-by-country basis and using a system estimation technique in order to impose common parameters across countries where such restrictions are consistent with the data. A striking feature of the results is that most of the countries accept a common sacrifice ratio.

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Ce papier présente des estimations de formes réduites d'inflation pour les pays de l'OCDE. Les principales variables explicatives sont l'écart au potentiel et l'inflation importée. Deux approches économétriques sont utilisées : des estimations pays par pays, puis une estimation en système qui permet de tester et éventuellement d'imposer la similarité des coefficients à travers les pays. Le résultat le plus intéressant de cette approche est que l'on obtient ainsi des estimations de ratios de sacrifice de même ampleur pour un grand nombre de pays de l'OCDE

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TESTING FOR A COMMON OECD PHILLIPS CURVE

Dave Turner, Elena Seghezza[1]

Introduction and Summary

1. Globalisation and rapid technological change are increasingly cited as undermining conventional macroeconomic relationships that attempt to explain inflation.[2] Evidence to the contrary is provided by this paper which shows that a simple Phillips curve relationship works well for most OECD countries, remaining stable over recent years, with a high degree of similarity in the estimated parameters across many countries. The key explanatory variable is a measure of the output gap that is published regularly in the *OECD Economic Outlook*, and which provides a basis of analysis and commentary on macroeconomic developments in OECD countries. The other important explanatory variable is imported inflation, to which there is some evidence that inflation in the larger European countries is more sensitive (even allowing for differences in openness) than either the United States or Japan, possibly reflecting differences in real wage resistance.

2. The Phillips curve relationship is one of the most important and controversial in macroeconomics. The original Phillips curve (Phillips, 1958) was attacked by Friedman (1968) for its prediction of a long-run trade-off between inflation and unemployment and dismissed by Lucas and Sargent (1978) as "being econometric failure on a grand scale". Subsequently, the re-specification of the Phillips curve to incorporate a vertical long-run trade-off and supply shocks led Gordon (1997) to claim that the empirical stability of such a relationship is such that "[t]he inflation process in the United States is one of the most important macroeconomic phenomena in the world, but it is also one of the best understood". However, even in the context of the United States, others have recently questioned the validity of the Phillips curve; for example, Galbraith (1997) argues that the empirical evidence for a vertical long-run Phillips curve is weak and has become weaker over the last decade.

3. The present paper examines the strength of the empirical evidence of a Phillips curve relationship between price inflation, the output gap and import inflation across twenty-one OECD countries. It further considers whether there is enough cross-country similarity in the relationship for common parameter restrictions to be imposed. The estimation work is conducted in two stages. In the first stage a simple Phillips curve specification is estimated separately across twenty-one OECD countries and the results examined for robustness and in particular the statistical significance of pressure of demand effects. In the

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1. Both authors are members of the Macroeconomic Analysis and Systems Management Division. Thanks to Jan-Cathryn Davies and Laurence Le Fouler for technical preparation and Jorgen Elmeskov, Pete Richardson and Stefano Scarpetta for comments on an earlier draft, although we accept sole responsibility for any remaining errors.

2. See the discussion in Gordon (1998), who is sceptical of such claims.

second stage the individual country equations are subjected to a system estimation approach, and tests are conducted to see how far common coefficient restrictions can be imposed across different countries.

4. The remainder of the paper is organized as follows. The first section describes the traditional specification used in the empirical literature on the Phillips curve and the particular specification adopted in this paper. The second section describes the estimation procedure. The third and fourth sections describe the single equation and system estimation results, respectively. Conclusions follow.

The Phillips curve specification

5. The "Phillips curve" is here taken, as in Gordon (1997), to describe "a generic term for any relation between the *rate of change* of a nominal wage or price and the *level* of a real indicator of demand in the economy". Gordon (1997) refers to the re-interpretation of the original Phillips curve to incorporate supply shocks and no long run trade-off as the "triangle" model of inflation whereby inflation depends on three basic determinants: inertia, demand and supply. This is the basis for the following general specification:

$$\pi = a(L)\,\pi_{-1} + b(L)\,D + c(L)\,z + e \qquad [1]$$

where the dependent variable is the inflation rate, inertia is captured by the lags of inflation, D is a measure of excess demand, z is a vector of supply shocks variables, a(.), b(.) and c(.) are polynomials in the lag operator L, subscripts denote lags and e is a serially uncorrelated error term. The restriction that the sum of the coefficients on lagged inflation values equals unity is imposed to ensure there is no long run trade-off between inflation and excess demand.

6. Different researchers have used different measures of excess demand D to estimate a Phillips curve relationship, including measures of labour market slack and capacity utilisation. As previously noted, the variable used here is the OECD Secretariat measure of the output gap, defined as the percentage difference between actual and potential real GDP, where the methodology underlying the calculation of potential output is described in Giorno *et al.* (1995).

7. The traditional Phillips curve specification of the 1960s and early 1970s did not include supply shock variables. This creates a potential omitted variables problem, because supply shocks, for example a sharp rise in energy prices, can create a negative correlation between inflation and the output gap implying a downward bias in the estimated coefficient on the output gap. Hogan (1998) finds that recent US inflation performance can only be adequately explained by a Phillips curve relationship when supply shocks arising from import price movements are incorporated into the specification. Following Hogan (1998), Gruen, Pagan and Thompson (1998) and Turner (1995), the equations estimated in this paper include an effect from imported inflation, which is arguably one of the most important supply shocks.

8. The original Phillips curve explained wage inflation, although many subsequent empirical applications, including the current paper, have been formulated in terms of price inflation. Gordon (1997) argues for the use of prices in the context of the United States partly on the grounds that this is of greater policy interest because price inflation is more clearly one of the ultimate targets of macro policy.

9. An omission from the general specification [1] is any explicit reference to price expectations. Even if expectations can be revised promptly, price adjustment can be delayed by wage and price contracts, and by the time needed for cost increases to pass through the various intermediate stages of production.

The role of the lagged inflation terms is to capture the dynamics of inertia, whether related to expectation formation, contracts, delivery lags or anything else.[3]

10. The particular specification of equation [1] used in this paper is such that changes in output price inflation are explained in terms of the output gap and changes in import inflation, with the following dynamic form:[4]

$$\Delta\pi = \alpha_1 \Delta\pi_{-1} + \alpha_2 \Delta\pi_{-2} + \alpha_3 \, GAP + \alpha_4 \, \Delta GAP + \alpha_5 \, [\omega_{-1} \, (\pi^m - \pi)]_{-1} \qquad [2]$$

where Δ denotes the first difference operator, subscripts denote lags and variables are defined as following:[5,6]

π = Inflation rate of business sector output deflator at factor cost;
GAP = Output gap, per cent difference between actual and estimated potential output;
ω = Ratio of imports of goods and services to GDP;
π^m = Inflation rate of imports of goods and services deflator.

This specification implies no long run trade off between the level of output and the level of inflation: a *temporary* increase in the output gap will lead to a permanent increase in inflation.[7] The extent of this trade-off is defined by a "sacrifice ratio" - denoting the number of percentage point years of output loss required to reduce inflation by one percentage point - which can be readily calculated from the parameters of the estimated equation.[8]

11. The form in which import price inflation enters equation [2] is such that any permanent change in the level of import prices (or import price inflation) is eventually *fully reflected* in an equivalent change in the level of output prices (or output price inflation). While the estimated equation is a reduced form relationship, such a long-run response would, for example, be obtained from a more complete wage-price system in which homogeneity is imposed throughout, but where there is "real wage resistance" to changes in import prices.[9] The speed of adjustment of output prices to import prices is assumed to be proportional to the degree of openness of the economy, but even for a relatively open economy the coefficient estimates reported later in the paper suggest that it typically takes more than a decade for anything close to complete pass-through from import to domestic prices to be completed. A number of country-specific dummy variables, mostly relating to the first oil shock, are also included to account for large residual errors and are detailed in the tables reporting the estimation results.

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3. This does, however, mean that the specification will not pick up any autonomous changes in the expectations formation process, which might, for example, be brought about by a change in policy regime.

4. For a few countries (Austria, Ireland, Sweden and Switzerland) where there is no dynamic ΔGAP term, the "level" GAP term is specified with a lag where this is empirically preferred to a contemporaneous GAP term.

5. The relatively parsimonious lag structure was adopted after preliminary investigation found that additional lags were statistically insignificant.

6. All data come from the OECD Economics Department's Analytical Data Base.

7. Here and throughout this note an increase in the output gap will refer to the situation where actual output increases relative to potential output.

8. The sacrifice ratio is calculated as $(1-\alpha1-\alpha2)/(4*100*\alpha3)$, where the division by 4 is required to convert the semi-annual change in a semi-annual rate of inflation to the annual change in an annualised rate. The calculation of the sacrifice ratio assumes that potential output is exogenous, but if persistence leads to effects from the output gap on potential then the concept is poorly defined.

9. See Layard *et al*. (1991) for further discussion of real wage resistance.

12. There is no clear economic rationale for including an intercept in the estimated equation: if output remains at potential and import and domestic inflation are equalised then there is no reason to expect a systematic change in inflation. Arguably, there may be a case to include an intercept term in this form of equation to capture the effect of omitted supply shocks. In practice, however, when an intercept term is included in the single equation estimation it is nearly always statistically insignificant and so is excluded from the analysis.

Estimation procedure

13. The general approach adopted is to estimate individual equations for each country by OLS and subject them to a range of misspecification tests. Only those equations that produce satisfactory results in term of these tests as well as plausible coefficient estimates are included in the system estimation exercise (described below).

14. Thus, equation [2] is estimated separately by OLS for twenty-one OECD countries using semi-annual data that, for most OECD countries, cover the period from the early 1970s to 1997. Due to the lack of data eight OECD countries are excluded: Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, Poland and Turkey.[10] Statistically insignificant dynamic variables ($\Delta\pi_{-1}$, $\Delta\pi_{-2}$ and ΔGAP) are dropped sequentially from the equation, although the GAP and imported inflation terms are retained regardless of significance or sign.

15. These equations are tested for autocorrelation (Breusch-Godfrey test for up to second order serial correlation), normality of the residuals (Jarque-Bera normality test), functional form (RESET test), the Chow forecast test (over the last three years of the sample) and Chow's structural stability test (dividing the sample period in two). The outcome of the test results are used to try to improve the equations, for example, the failure of the normality or functional form tests may suggest the need to include dummy variables for particular outliers.

16. After excluding countries for which it is not possible to estimate a satisfactory equation, the equations are used to form a system.[11] The main rationale for doing this is to try to standardize equation properties across countries, so that differences exist only where there is econometric evidence to support them. Tests on an initial OLS system estimation revealed the presence of correlation of contemporaneous residuals across countries, perhaps reflecting the omission of common international shocks and suggesting the need to use the method of Seemingly Unrelated Regression Estimation (SURE) rather than OLS.[12] Thus the system is estimated using SURE.

10. At the present time, the OECD Secretariat does not calculate an output gap for any of these countries.

11. Previous experience using this approach suggests that the inclusion of poorly specified equations (which are typically for smaller countries) in the systems estimation can lead to implausibly large changes in the common parameter values once restrictions have been imposed.

12. The SURE method estimates the system of equation exploiting any information on the correlation between contemporaneous errors across countries. The test to check for contemporaneous correlation of residuals across pool members is that proposed by Breusch and Pagan (1980). It is an LM test based on the sum of sample correlation coefficients of residuals across pool members.

17. To facilitate the test for a common sacrifice ratio, equation [2] is reparameterised in a non-linear form. Thus, subtracting $\Delta\pi_{-1}$ from both sides of equation [2] and re-arranging gives:

$$\Delta\Delta\pi = \beta_1 \Delta\Delta\pi_{-1} + \beta_2 [\Delta\pi_{-2} + \beta_3 GAP] + \beta_4 \Delta GAP + \beta_5 [\omega_{-1} (\pi^m - \pi)]_{-1}, \quad [3]$$

where $\beta_2 = (\alpha_1+\alpha_2-1)$ and $\beta_3 = \alpha_3/(\alpha_1+\alpha_2-1)$ and the α's are consistent with equation [2].[13]

In this form the test for a common sacrifice ratio is given by the restriction that the coefficient β_3 is the same across countries. This test is conducted sequentially as follows. First it is initially carried out on the two countries which have a long-run response from the output gap on inflation which is closest to the average across all countries (excluding outliers) based on the single equation results. If this restriction is valid at the 5 per cent significance level[14] it is imposed and the next country with the coefficient closest to this common coefficient is tested. This process is repeated until all countries have been tested.

18. Once the tests for a common sacrifice ratio have been completed (and imposed when data-acceptable), tests are carried out in the same manner to establish whether the speed of adjustment to import inflation is the same across countries (i.e. $-\beta_5/\beta_2$ is the same) as well as whether the dynamic coefficients on inflation (β_1 and β_2) are the same.

Single equation OLS estimation results

19. A summary of the estimation results for the preferred set of OLS equations is provided in Table 1. The equations perform reasonably well against a standard set of diagnostic tests. The average standard error across all estimated equations is about 1 per cent and for the G7 countries about 0.7 per cent. Two countries have particularly high standard errors: New Zealand and Portugal.

20. For all countries there is a correctly signed long-run effect from the output gap on inflation. The implied sacrifice ratio is statistically significant to at least the 5 (10) per cent level for sixteen (seventeen) out of the twenty-one countries examined, and for all G7 countries. It is not significant, at the 10 per cent level, for four countries: Denmark (significant at 11 per cent), Finland, Norway and New Zealand.[15] The magnitude of the sacrifice ratio is also quite similar across countries (see Figure 1), lying in a range of between 2 and 4 for eleven countries. It is very low (around 1.6) for Japan, Italy and the Netherlands, and quite high (around 7) for Norway. Finland has a sacrifice ratio of 38, although it is statistically insignificant.[16] [17] For nearly all countries, with the exception of the United States and Finland, the variable specified as the first difference of the output gap is not significant.

13. The sacrifice ratio is calculated as $-1/(4*100*\beta 3)$.

14. If the restrictions had only be imposed at 10 per cent significance level the final results would be only marginally different.

15. For the Nordic countries, substituting a measure of the output gap, which excludes the public sector from both the numerator and denominator, does not improve the significance of the output gap variable.

16. The results for Japan are, however, fragile to small changes in the equation specification.

17. Further investigation has found that the low estimate of the sacrifice ratio for Italy is sensitive to the measure of unemployment and the NAWRU, which is used in the calculation of the output gap. If, following the approach of other researchers, both unemployment and the corresponding NAWRU measure is based on data for the Centre-North region (only), then a re-estimated equation accepts the restriction that the sacrifice ratio is equal to the common estimate.

21. A possible issue for concern is that there is circularity in the estimated relationship between inflation and the output gap because estimates of the non-accelerating wage rate of unemployment (NAWRU), which is one component of the output gap, are derived from a Phillips-type wage equation (see Giorno *et al*. (1995)). Further work suggests that, in practice, this is not a problem because when the output gap is replaced by the implied unemployment gap (the difference between actual unemployment and the NAWRU) the estimation results deteriorate (rather than improve as they might be expected to do if circularity was important). Thus, re-estimating the preferred single equations with the unemployment gap in place of the output gap, leads to a fall in the number of equations for which the gap variable remains significant at the 5 per cent level from 16 to 6 (out of 21), and from 7 to 3 among the G7 countries.

22. For all the countries there is a correctly signed effect from import inflation, and for fourteen (fifteen) countries it is statistically significant to at least the 5 (10) per cent level. The strength of the results concerning the output gap is partially dependent on the inclusion of the import price inflation and dummy variables. Thus, if the import price inflation term is dropped from all equations, then the number of countries for which the sacrifice ratio is significant at the 5 (10) per cent level falls from sixteen (seventeen) to twelve (fourteen) and if all dummy variables are also excluded the number falls to eight (fourteen).

23. For four countries, Finland, Netherlands, New Zealand and Portugal, it was particularly difficult to obtain a satisfactory equation, therefore these countries are excluded from the system estimation exercise.[18] Portugal and New Zealand have very high standard errors, while Netherlands and Finland have implausible coefficients.

24. An aggregate OECD equation for all OECD countries for which data is available is also estimated. Output gaps and inflation are weighted together using GDP weights at 1991 purchasing power parities and measures of openness and import inflation are based on estimates which exclude intra-OECD trade. The estimated equation has a well-determined effect from both the output gap and import inflation with an implied sacrifice ratio of 3.2 (see the final column of Table 1).

System estimation results

25. The pooled estimation results are reported in Table 2 and the residuals plotted in Figure 2. The average standard error across all equations is about 0.9 per cent, although it is higher for Australia, Denmark and Ireland (1.2 per cent) and Sweden (1.7 per cent).

26. Fifteen out of the seventeen countries accept the common sacrifice ratio, which is estimated to be 3.7 (Table 3 reports the Wald tests).[19] Amongst the G7, the United States, Germany, France, United Kingdom and Canada accept the common sacrifice ratio. Japan and Italy do not accept this common restriction, with lower estimated sacrifice ratios of 1.8 and 1.6, respectively. By imposing a common sacrifice ratio among almost all of the countries the dispersion of the system estimates is reduced relative

18. In the case of both Finland and New Zealand this may be because estimates of the output gap are particularly difficult to estimate; for Finland because the economy was subject to large shocks in the 1990s and for New Zealand because of major structural reforms from the mid-1980s.

19. Sensitivity analysis suggests that the sequence in which the restrictions are tested only have a slight effect on the final results. For example, if the test for a common speed of adjustment to imported inflation is carried out prior to the tests for a common sacrifice ratio then: the number of countries which accept a common sacrifice ratio falls from 15 to 13 (Ireland and Greece no longer accept the common sacrifice ratio); the estimate of the common sacrifice ratio is 3.8 rather than 3.7; and the number of countries which accept a common speed of adjustment to imported inflation is 10 rather than 11 (Spain no longer accepts it).

to the results for the single equation estimates as illustrated in Figure 1, although there is still significant variation in the dynamic response of inflation to a change in the output gap (Figure 3 and Figure 4). The sacrifice ratio for the aggregate OECD equation, estimated as a single equation and reported in the final column of Table 1, also easily accepts the restriction that the sacrifice ratio is equal to 3.7.

27. Eleven countries accept a common speed of adjustment to imported inflation (United States, Japan, Germany, Canada, Australia, Austria, Greece, Denmark, Ireland, Norway and Spain). The implied speed of adjustment of output prices to a change in import prices is plotted in Figure 5 (for G7 countries) and in Figure 6 (for the smaller countries). Because import price inflation is weighted by the degree of openness, the system estimates give rise to different adjustment speeds, *even* for those countries that accept the common long-run coefficient. Thus for the G3 countries, even though all accept the common long-run coefficient to imported inflation, there is a clear ranking of the speed of adjustment of domestic prices to a change in import prices reflecting the degree of openness of the economy: half the adjustment is completed within seven years for Germany, but it takes thirteen years for the United States and fifteen years for Japan. More generally, eight countries complete at least 50 per cent of the long-run adjustment within five years, and twelve countries 80 per cent adjustment within fifteen years.

28. The relative speed of adjustment to imported inflation can alternatively be compared across countries, but allowing for the degree of openness, in order to derive an indicator of the degree of real wage resistance. Thus, $\alpha_5/(1-\alpha_1-\alpha_2)$ corresponding to expression [2] for the single equation estimation, or $-\beta_5/\beta_2$ corresponding to expression [3] for the system estimation, equals the steady-state rate of change in inflation for a given disturbance to the wedge between import and output prices (normalised for the degree of openness) and provides a measure of real wage resistance. On this basis the results suggest there is some evidence that real wage resistance is higher in the European Union than in the United States, and (less clearly) that real wage resistance is slightly higher in the United States compared to Japan (see Figure 7 and Tables 1 and 2 for individual country results). There are, however, important differences within the European Union: most of the larger European countries, with the exception of Germany, have a higher degree of real wage resistance than the United States; and Germany, and most of the smaller European countries have a measure of real wage resistance which is insignificantly different to the United States in the system estimation.

29. In the unrestricted system the total number of freely estimated coefficients (excluding dummies) over the seventeen countries is 70, but the final preferred system of equations has only 27 freely estimated coefficients. Thus, forty-three coefficient restrictions have been imposed on the unrestricted system: fourteen restrictions with respect to the sacrifice ratio, ten with respect to the effect of imported inflation and nineteen regarding common dynamics. A global test of all these restrictions applied simultaneously (rather than sequentially) is easily accepted at the 5 per cent significance level.

Conclusions

30. The absence of any systematic relationship between measures of excess demand and inflation would make the conduct of macroeconomic policy extremely problematic. However, evidence presented in this paper provides support for such a relationship across a majority of OECD countries considered.

31. The single equation results suggest that for sixteen out of the twenty-one OECD countries examined there is a well determined long-run effect from the output gap on inflation. Although, in some cases, tests reject the imposition of common coefficients, there is a high degree of similarity across all the countries being considered. In particular, using a system estimation technique (on a slightly smaller sample of seventeen countries) it is possible to impose the restriction that all but two countries have a common sacrifice ratio of about 3¾. The system results also suggest a similar speed of adjustment of output price

inflation to changes in import price inflation for eleven countries, once account is taken of the degree of openness of the economy. However, the speed of adjustment is typically faster for European Union countries, particularly the larger ones, which may reflect a higher degree of real wage resistance.

32. In respect of the recently-formed European Monetary Union, the results provide some encouraging evidence that the inflationary response of individual member countries to the output gap is similar, although they also suggest that the responses to changes in import inflation differ across member countries. The direct relevance of the latter may now be limited given the importance of intra-EMU trade, except to the extent that it reflects different responses to supply shocks more generally.

33. The estimation work reported here might easily be extended in several directions, including testing for the inclusion of a richer set of supply-shock explanatory variables, for explicit forward looking expectations of inflation and non-linear effects from the output gap on inflation. Nevertheless, the overall results provide strong support for the empirical regularity of the re-specified Phillips curve in explaining inflationary developments across a substantial majority of OECD countries.

Table 1. **Summary of final OLS price equation results for individual countries**[a]

Dependent variable: $\Delta\pi$	United States	Japan	Germany	France	Italy	United Kingdom	Canada	Australia	Austria	Belgium	Denmark
Estimation period	64:2-97:2	70:1-96:2	69:1-97:2	70:1-97:2	63:1-97:2	71:1-97:2	71:1-97:2	67:1-97:2	73:2-97:2	73:2-97:2	69:1-97:2
$\Delta\pi(-1)$	-0.47***	-0.28***	-0.42***	-0.58***	-0.42***		-0.55***	-0.44***	-0.91***	0.36***	-0.30***
$\Delta\pi$ (-2)		-0.21**	-0.17***	-0.35***	-0.24***				-0.45***	-0.56***	-0.33***
$[\omega_{-1}*(\pi^m - \pi)]_{-1}$	0.37**	0.23	0.32***	0.65***	0.59***	0.95***	0.17	0.50**	0.58***	0.12***	0.23*
ΔGAP(*100)	0.07***										
GAP*(100)	0.10***	0.21***	0.07**	0.14**	0.25***	0.10**	0.08**	0.15**		0.05**	0.11(11%)
GAP(-1)*(100)									0.12*		
Other explanatory variables[b]											
Sacrifice ratio	3.6***	1.7***	5.8**	3.4**	1.6***	2.6**	5.0**	2.3**	4.7*	6.5**	3.7(11%)
Real wage resistance[c]	0.25	0.15	0.20	0.34	0.36	0.95	0.11	0.35	0.25	0.10	0.14
Standard error (per cent)	0.31	0.96	0.46	0.74	0.88	0.96	0.68	1.18	0.87	0.26	1.14
Diagnostic Tests (probabilities)											
Chow Test (1981:S1)	0.73	0.14	0.21	0.53	0.21	0.10	0.17	0.12	0.99	0.67	0.32
Chow Forecast Test (1994:2)	0.81	0.84	0.70	0.60	0.78	0.58	0.96	0.87	0.07	0.97	0.97
Reset Test	0.87	0.30	0.34	0.20	0.61	0.07	0.51	0.19	0.79	0.99	0.84
Serial Correlation LM(2) Test	0.32	0.97	0.45	0.63	0.57	0.96	0.44	0.21	0.10	0.84	0.55
Jarque-Bera Normality Test	0.77	0.81	0.27	0.56	0.65	0.94	0.72	0.68	0.30	0.17	0.76

a) Coefficients which are statistically significant at the 1, 5 and 10 per cent significance level are denoted by ***, ** and * respectively. For the diagnostic tests the probability value is reported (a value higher than 0.05 means that the null of no mis-specification cannot be rejected at the 5 per cent probability level).

b) Dummies for United States: 1973:2 = 1; 1974:2 = 1; 1975:2 and 1976:1 = -1
Dummies for Japan: 1974:1 = 1; 1975:1 = -1; 1990:2 = -1, 1991:1 = 1, 1991:2 = -1
Dummies for Germany: 1970:1 = 1; 1975:2 = -1; 1978:2 = 1, 1979:1 = -1
Dummies for France: 1982:2 = -1; 1986:1 = 1
Dummies for Italy: 1973:1 = 1; 1975:2 = -1; 1980:2 = -1
Dummies for United Kingdom: 1975:1 = 1; 1977:2 = -1, 1978:1 = 1; 1979:2 = 1
Dummies for Canada: 1973:2 =1; 1975:1 and 1975:2 = -1; 1976:2 = -1; 1981:1 = 1, 1981:2 = -1
Dummies for Australia: 1974:2 = 1, 1975:1 = -1; 1994:2 and 1995:1 = 1
Dummies for Austria: 1974:1 = 1; 1975:1 = -1; 1979:2 = -1
Dummies for Belgium: 1973:2 = 1; 1975:2 and 1976:1 = -1; 1977:1 and 1977:2 = -1; 1979:2 = -1
Dummies for Denmark: 1989:1 = 1

c) The measure of real wage resistance is calculated as the coefficient on $[\omega_{-1}*(\pi^m - \pi)]_{-1}$ divided by 1 minus the coefficients on $\Delta\pi(-1)$ and $\Delta\pi(-2)$.

Table 1 *cont'd.* **Summary of final OLS price equation results for individual countries**[a]

Dependent variable: $\Delta\pi$	Finland	Greece	Ireland	Norway	Netherlands	New Zealand	Spain	Portugal	Sweden	Switzerland	OECD
Estimation period	72:2-97:2	71:2-97:2	72:2-97:2	67:1-97:2	74:1-97:2	75:1-97:2	67:1-97:2	63:1-97:1	67:1-97:2	73:1-97:2	76:2-97:1
$\Delta\pi(-1)$	-0.42***	0.41***		0.40***	-0.32**	-0.83***	-0.17**	-0.37***	-0.70***	-0.69***	-0.26*
$\Delta\pi$ (-2)	-0.36***	-0.45***	-0.29***	-0.55***		-0.54***		-0.46***	-0.39***	-0.21**	
$[\omega_{-1}*(\pi^m - \pi)]_{-1}$	0.53***	0.13	0.09	0.25**	0.17***	0.88***	0.57***	0.01	0.94***	0.04	0.55***
ΔGAP(*100)	0.25***										
GAP*(100)	0.01	0.10***		0.04	0.20**	0.14	0.11**	0.19**			0.10***
GAP(-1)*(100)			0.15**						0.18**	0.15***	
Other explanatory variables[b]											
Sacrifice ratio	38	2.5***	2.2**	7.3	1.6***	4.1	2.6**	2.4**	3.0**	3.1***	3.2**
Real wage resistance[c]	0.30	0.13	0.07	0.22	0.13	0.37	0.49	0.01	0.45	0.02	0.44
Standard error (per cent)	0.91	0.82	1.04	0.90	0.79	3.50	1.04	2.08	1.54	0.73	0.26
Diagnostic Tests (probabilities)											
Chow Test (1981:S1)	0.54	0.16	0.84	0.31	0.32	0.47	0.34	0.19	0.47	0.24	0.39
Chow Forecast Test (1994:2)	0.49	0.10	0.46	0.40	0.93	0.97	0.85	0.99	0.33	0.71	0.99
Reset Test	0.21	0.92	0.38	0.66	0.00	0.96	0.60	0.82	0.63	0.20	0.58
Serial Correlation LM(2) Test	0.17	0.16	0.86	0.16	0.21	0.13	0.52	0.18	0.30	0.06	0.97
Jarque-Bera Normality Test	0.28	0.77	0.99	0.29	0.96	0.23	0.33	0.65	0.44	0.43	0.68

a) Coefficients which are statistically significant at the 1, 5 and 10 per cent significance level are denoted by ***, ** and * respectively. For the diagnostic tests the probability value is reported (a value higher than 0.05 means that the null of no mis-specification cannot be rejected at the 5 per cent probability level).

b) Dummies for Finland: 1973 = 1; 1974:1 = 1; 1974:2 and 1975:1 = - 1; 1979:2 = -1; 1996:2 = -1
Dummies for Greece: 1972:2 = 1; 1974:1 = 1, 1974:2 = -1; 1975:1 = -1, 1975:2 = 1
Dummies for Ireland: 1973:2 = -1; 1975:1 = 1; 1981:1 = 1; 1993:1 = 1
Dummies for Norway: 1969:2 = 1; 1988:2 = -1; 1994:2 = 1
Netherlands: ΔGAP(-1) was included, its coefficient is -0.40 and it is significant at 1 per cent. Dummies: 1979:2 = 1
Dummies for New Zealand: 1975:2 and 1976:1 = 1, 1976:2 = -1
Dummies for Spain: 1973:2 = 1; 1974:2 = -1; 1968:2 = -1; 1984:2 = -1
Dummies for Portugal: 1977:1 = 1; 1982:2 = -1, 1983:1 = 1
Dummies for Sweden: 1970:2 = 1, 1971:1 = -1; 1978:2 = 1; 1979:2 = -1; 1996:1 = -1
Dummies for Switzerland: 1976:1 = -1; 1977:2 and 1978:1 = 1; 1983:1 = -1; 1992:1 = -1

c) The measure of real wage resistance is calculated as the coefficient on $[\omega_{-1}*(\pi^m - \pi)]_{-1}$ divided by 1 minus the coefficients on $\Delta\pi(-1)$ and $\Delta\pi(-2)$.

Table 2.

A. **Summary of system estimation results: G7 countries**[a]

Dependent variable: $\Delta\Delta\pi$	United States	Japan	Germany	France	Italy	United Kingdom	Canada
Estimation period	64:2-97:2	70:1-96:2	69:1-97:2	70:1-97:2	63:1-97:2	71:1-97:2	71:1-97:2
$\Delta\Delta\pi(-1)$	-1.52***	-1.29***	-1.52***	-1.60***	-1.29***	-1.02***	-1.52***
$\Delta\pi$ (-2)	-1.64***	-1.49***	-1.64***	-1.95***	-1.49***	-1.00***	-1.64***
$[\omega_{-1}*(\pi^m - \pi]_{-1}$	0.33***	0.30***	0.33***	0.72***	0.52***	0.99***	0.33***
ΔGAP(*100)	0.06*						
GAP*(100)	0.11***	0.21***	0.11***	0.13***	0.23***	0.07***	0.11***
GAP(-1)*(100)							
Sacrifice ratio	3.7***	1.8***	3.7***	3.7***	1.6***	3.7***	3.7***
Long-run wage resistance[b]	0.20	0.20	0.20	0.37	0.35	0.99	0.20
Standard error (per cent)	0.33	1.01	0.51	0.77	0.92	1.03	0.74

B. **Summary of system estimation results: smaller OECD countries**[a]

Dependent variable: $\Delta\Delta\pi$	Australia	Austria	Belgium	Denmark	Greece	Ireland	Norway	Spain	Sweden	Switzerland
Estimation period	67:1-97:2	73:2-97:2	73:2-97:2	69:1-97:2	71:2-97:2	72:2-97:2	67:1-97:2	67:1-97:2	67:1-97:2	73:1-97:2
$\Delta\Delta\pi(-1)$	-1.52***	-1.94***	-0.60***	-1.29***	-0.60***	-0.99***	-0.60***	-1.29***	-1.76***	-1.52***
$\Delta\pi$ (-2)	-1.64***	-2.40***	-1.11***	-1.49***	-1.11***	-1.20***	-1.11***	-1.49***	-2.16***	-1.64***
$[\omega_{-1}*(\pi^m - \pi]_{-1}$	0.33***	0.49***	0.10***	0.30***	0.22***	0.24***	0.22***	0.30***	0.92***	0.03
ΔGAP(*100)										
GAP*(100)	0.11***		0.07***	0.10***	0.07***		0.07***	0.10***		
GAP(-1)*(100)		0.16***				0.08***			0.14***	0.11***
Sacrifice ratio	3.7***	3.7***	3.7***	3.7***	3.7***	3.7***	3.7***	3.7***	3.7***	3.7***
Long-run wage resistance[b]	0.20	0.20	0.09	0.20	0.20	0.20	0.20	0.20	0.43	0.02
Standard error (per cent)	1.25	0.93	0.29	1.19	0.86	1.25	0.82	1.12	1.66	0.71

a) Coefficients which are statistically significant at the 1, 5 and 10 per cent significance level are denoted by ***, ** and * respectively. The dummy variables which were included in the individual OLS equations are also included in the system.

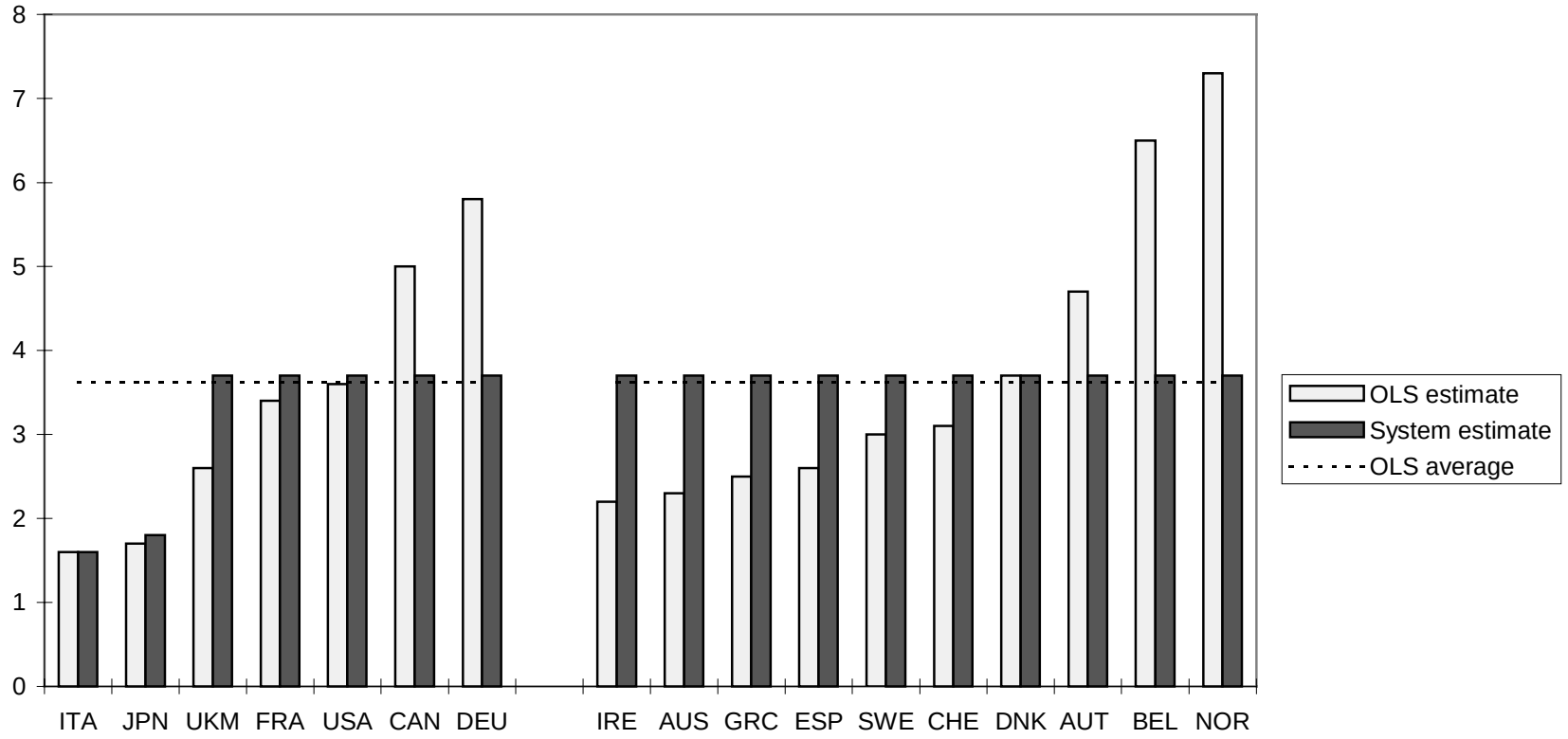
b) The measure of real wage resistance is calculated as the coefficient on $[\omega_{-1}*(\pi^m - \pi)]_{-1}$ divided by (minus) the coefficients on $\Delta\pi(-2)$.

Table 3. **Wald tests of restrictions imposed in the system estimation**[a]

Common sacrifice ratio[b]	P-values	Common dynamics[c]	P-values	Common speed of adjustment of import prices[d]	P-values
United States, France	0.88	First group of common dynamics		Greece, Norway	0.95
United States, France, United Kingdom	0.66	United States, Australia	0.93	Greece, Norway, Austria	0.90
United States, France, United Kingdom, Austria	0.68	United States, Australia, Germany	0.11	Greece, Norway, Austria, Germany	0.74
United States, France, United Kingdom, Austria, Canada	0.50	United States, Australia, Germany, Canada	0.37	Greece, Norway, Austria, Germany, Australia	0.75
United States, France, United Kingdom, Austria, Canada, Norway	0.70	United States, Australia, Germany, Canada, Switzerland	0.07	Greece, Norway, Austria, Germany, Australia, United States	0.64
United States, France, United Kingdom, Austria, Canada, Norway, Spain	0.52			Greece, Norway, Austria, Germany, Australia, United States, Japan	0.60
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland	0.70	Second group of common dynamics		Greece, Norway, Austria, Germany, Australia, United States, Japan, Denmark	0.21
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark	0.78	Denmark, Japan	0.59	Greece, Norway, Austria, Germany, Australia, United States, Japan, Denmark, Ireland	0.12
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece	0.13	Denmark, Japan, Italy	0.47	Greece, Norway, Austria, Germany, Australia, United States, Japan, Denmark, Ireland, Spain	0.22
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece, Australia	0.12	Denmark, Japan, Italy, Spain	0.18	Greece, Norway, Austria, Germany, Australia, United States, Japan, Denmark, Ireland, Spain, Canada	0.13
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece, Australia, Ireland	0.06				
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece, Australia, Ireland, Germany	0.29	Third group of common dynamics			
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece, Australia, Ireland, Germany, Belgium	0.23	Greece, Belgium	0.28		
United States, France, United Kingdom, Austria, Canada, Norway, Spain, Switzerland, Denmark, Greece, Australia, Ireland, Germany, Belgium, Sweden	0.68	Greece, Belgium, Norway	0.86		

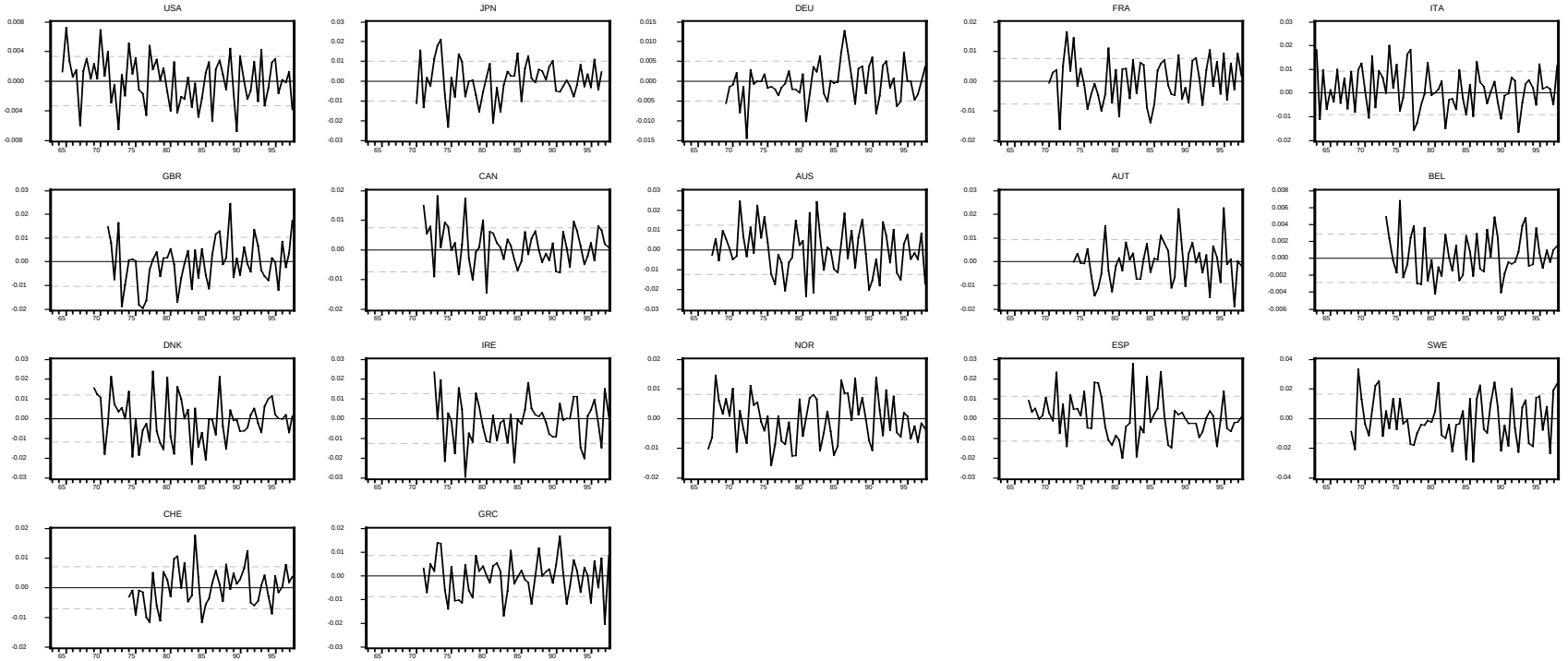
a) The p-values indicate the probability of obtaining a test-statistic whose absolute value is greater than or equal to the sample statistic if the null hypothesis is true.
b) Null Hypothesis: the sacrifice ratio ($-1/(400*\beta_3)$) of the last country specified is equal to that of the other countries in the list.
c) Null Hypothesis: the inflation dynamics of the last country specified is equal to that of the other countries in the list.
d) Null Hypothesis: the speed of adjustment to imported inflation ($-\beta_5/\beta_2$) of the last country specified is equal to that of the other countries in the list.

Figure 1. **Estimates of the Sacrifice Ratio**



Country abbreviations are as follows: USA = United States, JPN = Japan, DEU = Germany, FRA = France, ITA = Italy, UKM = Great Britain, CAN = Canada, AUS = Australia, AUT = Austria, BEL = Belgium, DNK = Denmark, FIN = Finland, GRC = Greece, IRE = Ireland, NOR = Norway, NLD = Netherland, NZL = New Zealand, ESP = Spain, PRT = Portugal, SWE = Sweden, CHE = Switzerland

Figure 2. **System Residuals**



For explanation of country abbreviations see Figure 1.
Scales are different for different charts.

Figure 3. **Inflation response to a temporary increase in the output gap for the G7 countries based on system estimates[(1)]**

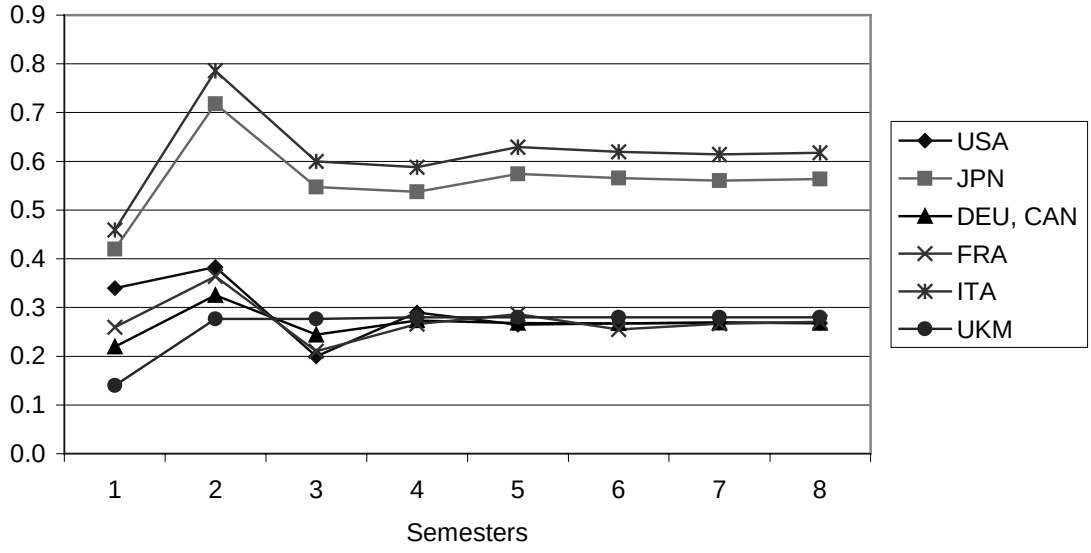
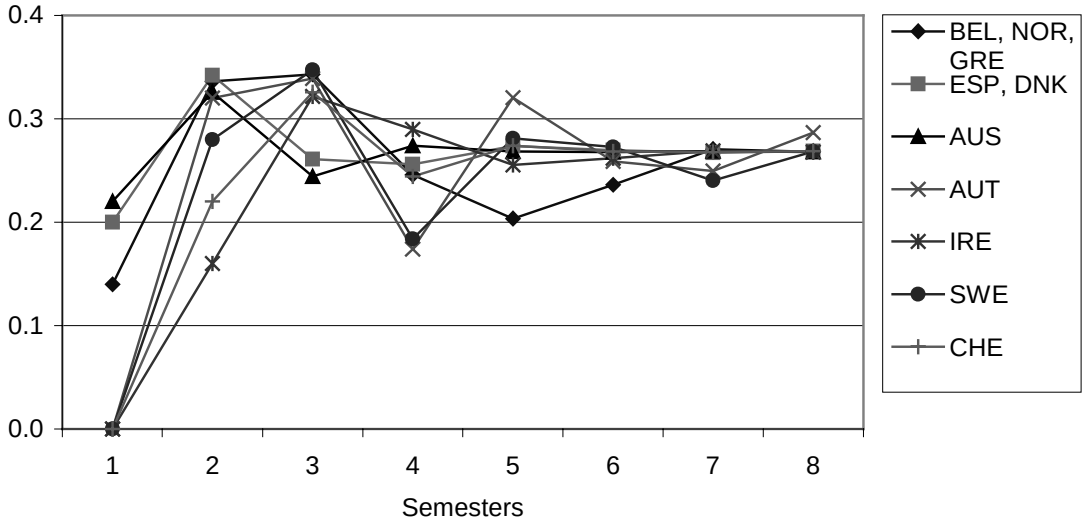


Figure 4. **Inflation response to a temporary increase in the output gap for the smaller OECD countries based on system estimates[(1)(2)]**



For explanation of country abbreviations see Figure 1.
(1) The temporary increase in the output gap is of one percentage point for one year.
(2) The scale of the two graphs is different.

Figure 5. **Output price response to a permanent increase in the import price level by one per cent for the G7 countries based on system estimates**

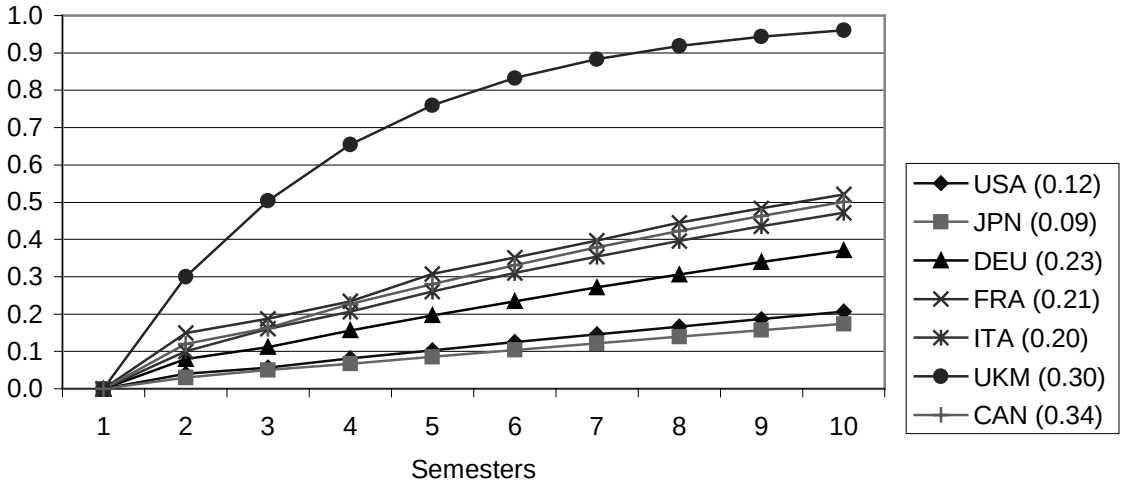
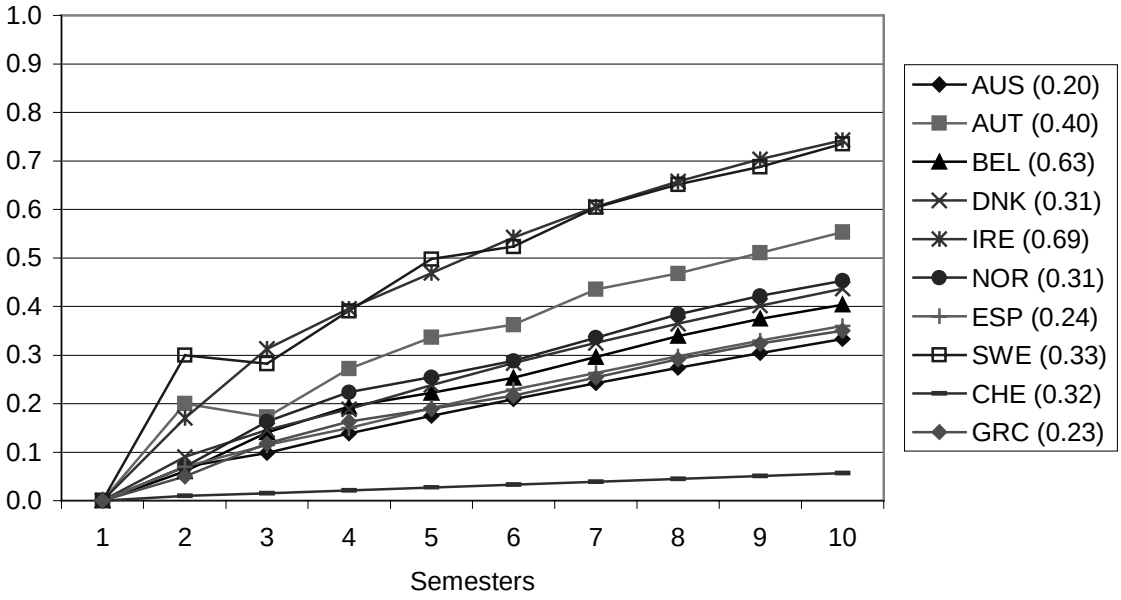
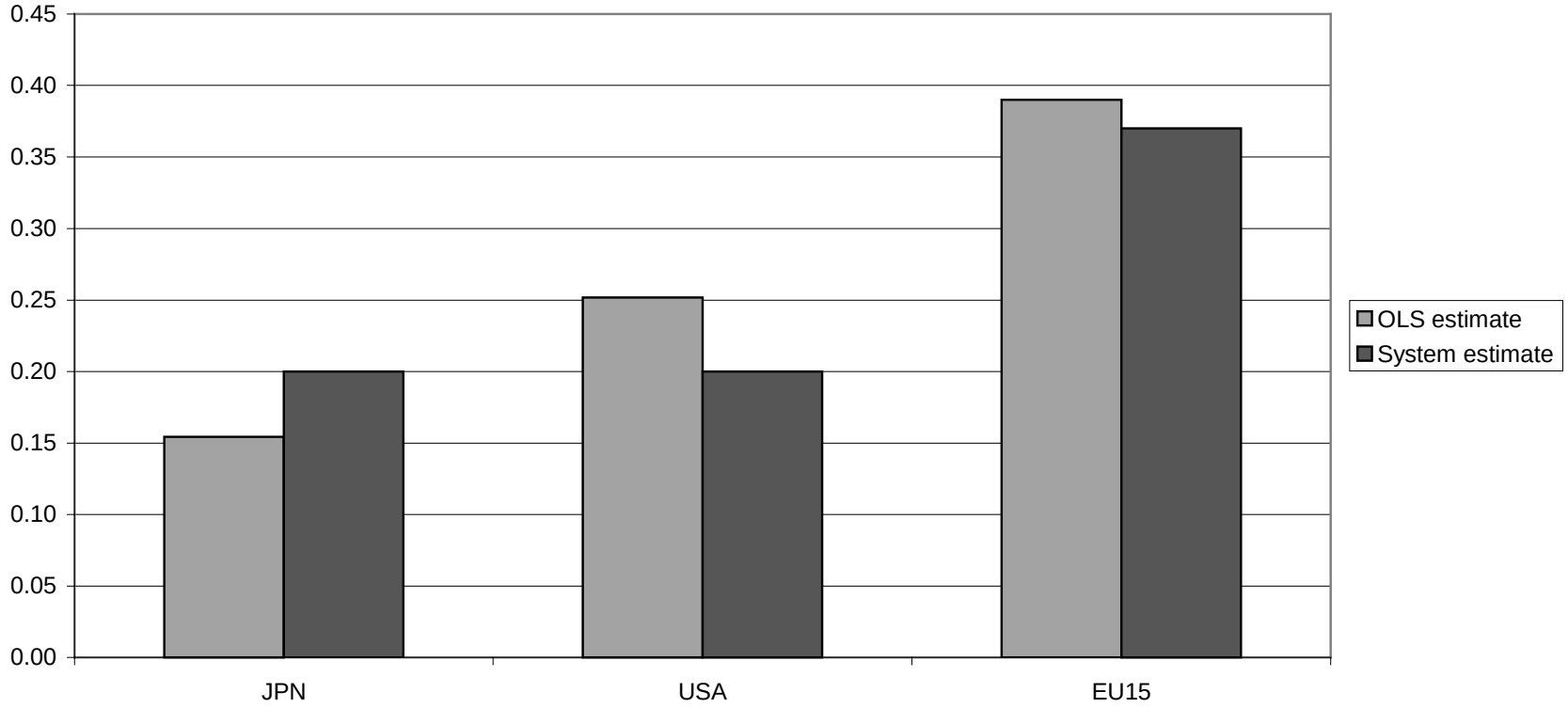


Figure 6. **Output price response to a permanent increase in the import price level for the smaller OECD countries based on system estimates**



For explanation of country abbreviations see Figure 1
The figure in parentheses is the degree of openness, calculated as the ratio of imports of goods and services to GDP in 1995S1

Figure 7**. Real wage resistance in the United States, Japan and European Union**



See text for discussion of how measures of real wage resistance are constructed from the equation estimates.
For the European Union the OLS and systems estimates are calculated as a weighted average (using the relative size of the labour force as weights) of the respective individual country estimates.

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