

ASYMMETRY AND THE PROBLEM OF AGGREGATION IN THE EURO AREA

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Abstract

This paper highlights the implications for EU macroeconomic policy at a relatively disaggregated level when key economic relationships are nonlinear or asymmetric. Using data for the EU and OECD countries we show that there are considerable non-linearities and asymmetries in the Phillips and Okun curves. High unemployment has relatively limited effect in pulling inflation down while low unemployment can be much more effective in driving it up. Downturns in the economy are both more rapid and sustained in driving unemployment up than recoveries are in bringing it down. There is considerable variety in these relationships and IS curves across not just countries but also sectors and regions.

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The euro area has a single monetary policy for quite a diverse region. While it is widely appreciated that monetary policy is a ‘blunt instrument’ and that what is appropriate for the euro economy as a whole may have adverse effects both for individual sectors and for particular geographical parts of the area,¹ some of the consequences of this for the setting of policy have been little discussed. Currently euro area policy simulations are either conducted with models that use euro level aggregated data or which handle the euro countries separately (with appropriate cross-country constraints) and aggregate the results.² Such aggregations are usually either unweighted or based on GDP or similar weights. However, these straightforward approaches are based on the assumption that the behaviour we seek to model is largely linear over the relevant range. In this paper we show that there are strong grounds for believing that there are substantial asymmetries and nonlinearities in inflationary behaviour and monetary transmission. Ignoring these could have substantial adverse effects on particular sectors, regions and member states within the euro area.

These themes have been dealt with in a number of different ways in the past and our analysis runs across them. In particular we combine the idea of asymmetric business cycles (Freidman, 1993; Kim and Nelson, 1999) with the evidence that sectoral patterns matter as an explanation of how asymmetric the response is on each occasion (Lilien, 1982; Davis *et al.* 1996; Haltiwanger and Schuh, 1999). It has long been suggested that business cycles may be asymmetric in a number of respects. Keynes (1936), for example, suggests that downturns may be sharper than upturns and consequently that recoveries take longer than declines. This asymmetry may occur even within fairly homogeneous economies or single sectors. Most explanations focus on the labour market, however, we suggest that policy may also be asymmetric. Haltiwanger and Schuh (1999) show that the bulk of adjustment tends to occur within each industrial sector rather than across them. In a recession there is far more shaking out of employment from some firms and absorption by others than in recoveries. If getting new jobs is costly, not just through search but because an element of re-training may be necessary then this will of itself generate asymmetry. If the change requires considerable inter-sectoral movement then the costs and hence the asymmetry will tend to be greater. This will be exacerbated in economies like the euro area where labour mobility between regions, not merely between member states, is decidedly limited.

These problems are not new and apply to any diversified economy. They are particularly obvious in small open economies where monetary policy has a very different bite on the tradeable sector from the nontradeable. The adjustment for inflationary pressures will be concentrated on those sectors that are most flexible and may not correspond to those where the inflationary pressure is greatest. In such an economy raising interest rates through monetary policy to reduce future infla-

¹ Dornbusch *et al.* (1998), Eichengreen and Wyplosz (1998), Obstfeld and Peri (1998) for example.

tionary pressures will also raise the exchange rate. Tradeable sectors will be then affected directly both by the exchange rate effect and the interest rate effect, whereas nontradeable sectors will only be directly affected by the interest rate and indirectly by the consequence of the exchange rate on the tradeable sectors. However, it is not uncommon to find that inflationary pressures are at their greatest in the housing and construction sector, which is one of the least tradeable (Mayes and Viren, 1998). Because it is difficult to expand supply rapidly, both through planning restrictions and through the size of the construction sector prices rise rapidly. Since buildings last for many years their prices behave like other asset prices and rise much more rapidly than the general price level in response to any increase in growth expectations.

Thus on the one hand policy may be relatively ineffective because its impact tends not to fall where the main problem lies. On the other the costs of policy may be higher in order to have the desired effect on inflation.

In a linear world all components in the price index are of ‘equal’ importance (i.e. as important as their weight in the index). Hence one can just as easily point to prices that are not falling ‘fast enough’ as causing overall inflation as to those that are rising fastest. But in a nonlinear world small changes in overall pressures lead to much more than proportionate increases in prices at the upper end of the distribution than to lesser declines at the lower. Similar asymmetric arguments are applied on the way down (Ball and Mankiw, 1995, for example). Menu costs lead people to leave prices alone when the need for change is small but then to move them by at least the full amount of the relative costs change when the time for a move comes.

Thus the word ‘asymmetry’ is used with several meanings in the current context but all are variations on the theme that behaviour is different either side of a specific value of a variable. In the context of business cycles three forms of asymmetry are normally discussed: *deepness* – do recessions tend to be deeper than booms are high (compared to some trend or sustainable growth path); *length* – do recessions tend to shorter than expansions and *steepness* – does the decline occur more rapidly than the recovery. Mayes (1986) extends this discussion to a wider area of applications – for example it takes a long time to build up a reputation but a single bad mistake can destroy it. Rebuilding a lost reputation can be even slower than the initial building.

In the context of the Phillips curve much of the discussion of ‘asymmetry’ relates to the fact that the relationship is not a straight line. Hence the relationship is asymmetric in that unemployment below the NAIRU will tend to result in increasing and eventually explosive inflation while excess unem-

² The NIESR NiGEM, The European Commission’s QUEST II, and the Netherlands Bank’s EUROMON have these features for example.

ployment will have a diminishing effect tailing away into insignificance. However, it is asymmetric in a different sense in the Ball (1993) Mayes and Chapple (1995) discussion of the 'sacrifice ratio'. Here the gains in terms of extra output when the output gap is positive are more than offset by the losses when a negative output gap has to open to return inflation to its previous level. In this case the relationship is not merely a curve but its shape depends upon whether the output gap is falling or rising.

The problem can be regional rather than sectoral. This is illustrated for the UK by Buxton and Mayes (1986). They show that it was unemployment in the region with the tightest labour market (the Southeast) that had the main impact on inflationary pressure in the economy as a whole. Unemployment in other regions where pressures were slacker had far less impact. Disinflationary policy, particularly during the 1970s and early 1980s, not merely increased the level of unemployment in the country but it increased the spread. In order to have an adequate impact on the tightest labour market average unemployment had to increase more than proportionately and the unemployment in the worst affected regions even more dramatically. The regional variation may occur simply because of the uneven distribution of the various sectors of the economy.

The euro area is different from most other currency areas in that it has considerable variation in the transmission of monetary policy even within the same sectors because of different institutions and traditions for financing economic activity and saving. This will complicate the nature of the differences in the impact and lead to another source of regional variation. As we explain below, some parts of the euro area could be persistently adversely affected if asymmetries are not taken into account.

None of this argument implies that running a single monetary policy is inappropriate. However it does have two other major implications. First, it implies that in setting monetary policy the ECB needs to take account of the problems of asymmetry and aggregation. Second, it entails that the governments of the member states both individually and jointly need to consider what other policy changes are needed in order offset the blunt nature of the impact of monetary policy. Structural and fiscal policies can be far better tuned to have detailed impacts on parts of the economy. This second message is not new and is not the focus of this paper. Our concern is to highlight the first implication, that for the setting of ECB monetary policy.

Much of the literature on asymmetry in EMU is misconceived for our purposes (list) as it focuses on the idea that individual countries will vote for the policy that would be best suited to their own needs and that the compromise or majority position may be suboptimal. We assume on the other hand that all those deciding on monetary policy are trying to do so from the point of view of what is

best for the euro area as a whole. We assume therefore that policy is made either on the basis of simple aggregates of behaviour to the euro level or by aggregating national outcomes using GDP weights. We therefore do not have to face any problems about whether policy is based on the median voter or the nature of qualified or other majorities. Our concern is simply that if arithmetic weights are used in a nonlinear and asymmetric world there is a danger of generating inefficient outcomes. Tarkka (1998) has already shown that inappropriate voting systems could make the result even worse.

Although previous analyses show the existence of the nonlinearities, asymmetries and aggregation problems we have described there does not appear to have been any systematic single analysis of the three problems together across the euro area as a whole. In this paper, therefore, we consider the issues using a dataset that covers all of the EU countries except Greece and Luxembourg.³ We thus cover not merely the current euro area but also the main countries that might join it over the coming few years. We use three different forms of disaggregation:

- sectoral asymmetric impact within an economy
- panel data on the asymmetric impact at the national level
- regional data at the NUTS3 level

and illustrate the problem with three well-known macroeconomic relationships: an IS curve, a Phillips curve and an Okun curve.

1 Aggregation

Before adding the complication of asymmetry we consider the importance of aggregation separately. In Mayes and Viren (1998) we provided estimates of an MCI (Monetary Conditions Index) for the euro area using a variety of models. The interest in estimating an MCI was to get an indication of the relative importance of the (real) exchange rate and (real) interest rates in the transmission of monetary policy through to inflation.⁴ The MCI summarises in a single index the joint effect of the two channels through to inflation. It does not of course include other transmission channels such as the direct effect on expectations or the credit channel (Mishkin, 1995). It is formed as the weighted sum of the two components where the weights are determined by the relative impact of the two channels on demand pressure.

Let us illustrate this with the simplest of the models, which was an open economy IS curve of the form

³ The data for Ireland are more limited and Greece and Luxembourg only excluded because the data were not available.

$$\nabla y_t = a_0 + a_1 \nabla y_{t-1} + a_2 \nabla y_{t-2} + a_3 rr_{t-k} + a_4 re_{t-k} + a_5 \nabla y^*_{t-k} \quad (1)$$

where ∇y is the deviation of output from its Hodrick-Prescott filtered trend, rr is the real 3-month interest rate, re the real exchange rate with the US dollar (in logs) and ∇y^* the deviation of OECD output from its HP trend (for definition of variables see Appendix). This is very similar to the equation used by Duguay (1994) in the original formulation by the Bank of Canada. The interest rate and exchange rate coefficients a_3 and a_4 suitably normalised provide the weights.⁵ The MCI ratio is computed simply as the ratio of the two coefficients, a_3/a_4 .

In order to provide a suitable estimate for the area as a whole we estimated (1) for each of the euro countries excluding Luxembourg (see Table 1) for the period 1987.1 to 1997.4. In order to compute an estimate for the euro area as a whole we simply aggregated these estimates using GDP weights. From this we can see that there is considerable variation across countries (Fig. 1 last col.) but also a concentration round the aggregate estimate of 3.5. If on the other hand we had assumed that parameters were the same across the euro countries, which we do in Table 2 by treating the data as a panel we can see that the results change and lower estimates are obtained in each case, although not strikingly so. Note that lower estimates imply that the exchange rate is even more important in the monetary transmission mechanism than we previously estimated. It is interesting to note from Row 3 of Table 2 (EU13) that adding the EU countries that are not currently members of the euro area (excluding Greece) has almost no impact on their relative responsiveness to the exchange rate although the estimate becomes rather more closely determined. However, when GLS or SUR estimation is applied the estimates become considerably smaller, smaller even than those in Dornbusch *et al.* (1998), and imply an implausibly open euro economy. Imposing similarity of behaviour on this definition of the EU would thus tend to generate inappropriate conclusions for policy and is clearly rejected by the data.

However, while there are clear problems in adding up the ratios computing the *level* of the MCI is much more difficult if the economic cycles of the Member States are not in phase, as it is the output gap which is relevant to their assessment. In such a case it would be inappropriate to estimate an MCI using aggregate data for the euro. Instead separate MCIs should be estimated at the disaggregated level and then aggregated.⁶ This is particularly important if the short-run Phillips curve is not

⁴ Both the use and estimation of MCIs are controversial (see Eika *et al.* 1997 and Mayes and Viren, 2000, for example) but this does not concern the present discussion.

⁵ In the MCI computed by the Reserve Bank of New Zealand the effects are scaled so that the impact of the two effects is one index point is the same as one basis point on interest rates, with the 1st December 1996 value set equal 1000.

⁶ It is not of course self-evident that it is the Member State level that is appropriate for the disaggregation. It should really be regions in which behaviour is fairly homogeneous. (Dupasquier, Lalonde and St-Amant (1997) demonstrate that in some cases there is more variation between some Canadian provinces than there is between Canada and the US.) Commodity price shocks may have regional rather than national impacts. However, the data to hand are on a Member State basis.

linear and positive output gaps have a much stronger impact on increasing inflation than negative gaps have on decreasing it. We, therefore, return to estimate the Phillips curve in section 3.

2 Aggregation within the economy

This problem of aggregation under nonlinearity or asymmetry does not merely occur when trying to aggregate across different economies. It exists within economies as well.

To give an indication of the importance of economic structure in the estimation of the MCI we disaggregated Finnish GDP into 8 main sectors, shown in Fig. 2, and estimated sectoral MCIs of the same form. As might be expected it is the highly traded sectors where the MCI is lowest: manufacturing, forestry and agriculture; and the resident sectors such as construction and hospitality where the MCI is higher.⁷ The immediate result is that differences in the relative impact of the interest rate and exchange rate channels of the transmission of monetary policy vary almost as much by sector as they do by country. Even if country variations in the MCI might be expected to fall as integration proceeds in the euro area, sectoral variations are likely to continue. However, increased openness will tend to make all sectors increasingly ‘tradeable’ even if their outputs are not readily traded. This will tend to lead to decreasing values for the MCI. At the same time, the transmission mechanism through the exchange rate will also be affected by the introduction of the euro. Area-wide trends would affect the average MCI ratio but it will depend upon the correlation between the innovations in the exchange rate and interest rate mechanisms in the individual countries as to whether their specific MCI ratios would fall or rise.

The same pattern emerges at the European level. Using the same panel of countries as in Table 2 we have also estimated IS curves at the sectoral level, for just four sectors: Agriculture, Industry, Construction and Services.⁸ The estimated MCIs follow the same pattern as before in order of decreasing openness: agriculture 1.0, industry 2.2, services 4.7 and construction 18 (see Fig. 3). However, the equation for agriculture is not well determined nor is the exchange rate coefficient for construction. Hence if shocks are sectoral their impact for monetary policy will be considerably different than if they are spread evenly across the whole economy.

⁷ In estimating the differential effect of shocks to the exchange rate on the various parts of the euro economy, regard will have to be paid not just to the country composition of trade for the various parts of the area but also to their industrial structure.

⁸ It was not possible to get disaggregated data for the period for Belgium or Ireland. Row 2 of Table 2 therefore shows the aggregate results for the remaining 11 (EU11) countries. The estimates are very similar to the other two aggregates of 10 or 13 countries.

Thus it matters for policy, not merely whether shocks are unevenly spread across the member states of the euro area but whether they are spread unevenly across industries. Or turning this argument round, the impact of a common shock will vary both by member state and by industry.

3 Nonlinearity and asymmetry

The archetypal nonlinear relationship in macroeconomics is the Phillips curve (Phillips, 1958). Indeed it is only partly an accident of history, with the collapse of the long run regularity and its replacement with a short-run expectations augmented curve (Phelps, 1967) that it should have been estimated as a straight line. Moreover the term ‘Phillips curve’ has been extended to include any relationship between some measure of excess demand/supply in the economy and a measure of inflation, rather than just the relationship between unemployment and wage inflation. In this section we focus on one of the more common variants, the relationship between the output gap and price inflation, as this has frequently been estimated in linear form (see Clark and Laxton, 1997, for a brief review).

In its simplest form the relationship is usually represented as

$$dp = a_0 + a_1 dp_{t-1} + a_2 dp^* + a_3 \nabla y + u \quad (2)$$

where p and y are defined as before but ∇y denotes an output gap, p^* is the foreign price (in domestic currency). In the estimated model a Hodrick-Prescott filter is used to estimate the trend.

Fig. 4 shows the results for the output gap using a simplified Phillips curve of the form

$$dp = a_0 + a_1 dp_{t-1} + a_2 dp^* + a_3 \nabla y^+ + a_4 \nabla y^- + u, \quad (3)$$

where $\nabla y^{+/-}$ denotes the values of the output gap when it is (positive/negative), for the EU countries in our sample for the shorter data period 1987 - 1997. Again, with the exception of Spain and Finland the results confirm to the expected asymmetry. A more complex analysis taking into account the cyclical position in each member state may thus be needed before the level of the MCI is going to have a reliable or transparent meaning.

If we take a very simplified example as shown in Fig 5 it is very obvious how ignoring asymmetry and aggregation problems could have an unfortunate effect for policy. Let us assume first of all that the relationship between inflation and the output gap is as shown by the curve in the figure. Then simple arithmetic aggregation of forecasts of the output gap for two countries/regions/industries, which generate two expected outcomes, one at A and the other at B, will give a result such as ‘gap’ shown on the horizontal axis (even if weights are used). Assuming the relationship is a straight line will result in forecast inflation being Δp_1 rather than the appropriate value Δp_2 . Under an inflation targeting regime this will tend to mean that the policy response will be rather harsher under the as-

sumption of a linear relationship than it should be. Indeed in the case illustrated, the correct policy decision would be to ease while the actual decision, wrongly assuming linearity, would be to tighten.

We have chosen the deliberately simplified case where both A and B are on the linear as well as the curvilinear relationships. In general the contribution of large negative output gaps to holding inflation down will be overestimated and the contribution of high positive gaps to driving inflation up will be under estimated.

However, this is assuming that there is a common relationship, which applies all of the euro economies. There is considerable evidence that there are important differences in the transmission mechanism across the member states. As a result one is not only trying to add inputs where the relationships are nonlinear but where the nonlinearity itself varies. We thus need to consider where each of the countries is on its own curve and add together the change in inflation that would stem from the impact of the single monetary policy on each country's output gap and then aggregate. From a practical policy point of view the use of a single linear relationship will only generate significant errors, if

- the shifts along the curves are expected to be substantial
- the nonlinearity is considerable
- the different countries have very different output gaps (their cycles are not well coordinated)
- the individual country relationships are very different from each other.

Since we have only limited numbers of observations we have made the problem rather simpler by representing the nonlinearity simply by a two facet line. This is in effect the same as having a regime shift model.

For the results shown in Table 3 we have employed a slightly more complex lag structure allowing two lags for both consumer and foreign prices, which we have here measured as import prices, so as to give a clear idea of the weighting that applies to the foreign price structure for each country. It is immediately clear from the first four rows of the Table that the hypothesis of symmetry is rejected whichever estimation method is used. GLS and SUR make the picture rather clearer yet do not weaken the overall explanatory power. In each case the positive output gap shows a clearly positive relationship, while the negative output gap does not appear to exert any significant influence on inflation either upwards or downwards. The estimated coefficient for the constrained linear relationship shown in the first row not surprisingly lies between these two extremes. The results for the panel data for the EU show a rather firmer dichotomy than did the simple individual country model (see Fig. 6).

We now have a strikingly implication for policy. When the output gap is negative this will exert very little downward influence in its own right on inflation. Attempts to run the economy in over expansionary manner will on the other hand have substantial and quite rapid effects on inflation. There is therefore a strong incentive to avoid inflationary pressures taking hold. With this asymmetric model the costs of pursuing a price level as opposed to an inflation target could be considerable.

The choice of a zero output gap as the point round which to split the data is somewhat arbitrary. Although by construction of the output gap variable this will be a split around the mean value. Other splitting points might perform better empirically but a search over the range reveals that the errors are minimised at a value of -0.005 for the output gap. Not only is this virtually the same as zero but the coefficients in the equation are largely unaffected (Table 3, row. 4).

If we assume that the actual relationship should be a curve and that there is unlikely to be any sharp regime shift around the zero gap then this model will tend to underestimate the importance of the output gap for small negative values and overestimate it for small positive values. Values nearer the original single line will tend to be most appropriate. At large negative and positive gaps the mis-estimation will be the other way round. The line will overestimate the importance of large negative output gaps and underestimate the importance of large positive gaps, possibly exponentially so, depending on the shape of the curve, as limits are likely to be approached in both dimensions.⁹

If we consider the implications for policy at a national rather than euro area level. Countries with positive output gaps should have a much more important influence on monetary policy than those with negative gaps. Or turning the argument round, if policy is set symmetrically it will tend to have an inflationary bias.

Pyyhtiä (1999) using a similar model but with fewer countries and semi-annual data (without lags) obtains similar results for the pooled model. When the individual countries are estimated separately the pattern of the coefficients is similar in all cases, with positive gaps having a greater effect than negative gaps. Only in the case of Germany does the coefficient for the negative gap approach significance but the positive gap coefficients are not particularly strong except in the case of Italy. However, Pyyhtiä's main focus is on a curvilinear specification, using a quadratic representation of

⁹ We tried moving one step closer to estimating a curve by using a three facet curve. With such a small dataset it is not surprising that the parameters were not well determined by the result did suggest that a smoother transition might be more realistic.

the output gap. Adding the quadratic term improves the explanation for 5 out of the 7 countries in the sample but the findings are relatively weak even in the pooled case.

4 Not just a problem for the EU

However, we are not seeking to argue that the euro area is somehow different from other monetary regimes. Even within quite small countries there is considerable variation in the response of individual sectors. Thus using aggregate information may also be misleading in these cases as well. The most obvious way to reformulate the problem would be to disaggregate the data one step and look at regional data within each country. A fairly extreme example of how different the regional effects can be is shown in Buxton and Mayes (1986) using UK regional data, where the region with the lowest unemployment (the South East) is shown to have a major impact on wage inflation. More than that it appeared to be short-term unemployment that had the effect. Those employed for a year or more appeared to be effectively out of the labour market from the point of view of affecting the inflationary process.

Unfortunately it is relatively difficult to disaggregate as regional data do not cover the same variables particularly well. We have therefore used the nearest information readily available. This is drawn from the Eurostat Regio database at the NUTS3 level for the EU.¹⁰ NUTS3 has some 251 regions for this subset of countries. The data are annual running over the years 1984-98. Not all years are available for each country so we only obtain some 153 observations out of the potential 180. In this case we to use a different approach to the problem and consider not just the level of unemployment but its distribution across the regions. The hypothesis is that the greater the range/variance of unemployment at any given level of average unemployment then the more inflationary will be the impact as the low unemployment regions will contribute to inflationary pressure for the EU as a whole. This can be regarded as an extension to the Lilien index (Lilien, 1982; Mayes and Silverstone, 1998)

$$L = \sqrt{[\sum_i w_i (e_i - E)^2]}, \quad (4)$$

where e_i is the rate of growth of employment in region or sector i and E is the growth of employment in the area as a whole, w_i being the weight, the share of employment in that region in the total. Lilien's hypothesis is that the greater the dispersion of growth rates in employment the higher is likely to be the unemployment rate. This reflects the idea that it is costly to retrain or move labour. Purely macroeconomic statistics will cover up the consequences of this. If growth is not evenly spread then the more rapidly growing regions will not be as successful in reducing unemployment elsewhere as the less rapidly growing regions are at creating unemployment.

We are not able to formulate the problem in quite the same dynamic context and consider the variance in unemployment across the regions instead. Here the argument is a little different. Following our aggregate findings for a nonlinear Phillips curve we would expect that regions with high unemployment tend to have relatively little impact on reducing inflation, whereas regions with low unemployment have an increasingly positive effect as unemployment falls. Measures of variance are a second best for our purpose as they are symmetric. Nevertheless, a wider range or standard deviation will tend to indicate the existence of these lower unemployment regions compared to the average and hence a greater impact on inflation for any given level of unemployment for the country as a whole.

We are able to improve on the simple forms of the Phillips curve used in Fig. 4 and Table 3 as we now have annual data. This allows us to incorporate a measure of expectations directly into the relationship. We use the same forward looking measure as Pyh tti  (1999), namely, the OECD's published forecasts of inflation for each country made one year ahead drawn from the successive issues of *Economic Outlook*.

We can see from Table 4 that this hypothesis is borne out whether we use the range $U_{max}-U_{min}$ or the standard deviation Usd as the measure of variance. Variance in unemployment across regions has a positive effect on inflation. It is also clear from the comparison of columns 1 and 3 and 2 and 4 that the individual member states react differently. Inserting shift dummies into the equation improves the fit of the basic Phillips curve considerably, increasing the (negative) impact of average unemployment substantially while also increasing both the size and the significance of the positive impact of the spread.

In column 6 of Table 4 we try adding the asymmetry in the Phillips curve itself by replacing the single (linear) relationship by a two-piece linear relationship, allowing the relationship to be different according to whether unemployment is above or below its approximate average value of 8% for the period as a whole. The difference in slope of the two coefficients is not substantial but it is significant at the 2% level. What is surprising however is that both coefficients are smaller in (absolute) value than the simple linear relation and that higher unemployment has a greater impact on inflation. This perversity has been recorded for the US (Gordon, 1997; Stiglitz, 1997) but may in this instance be the result of some interaction with the measure of variance as it is likely that the mean and variance of unemployment are correlated.

In the second half of Table 3 we show the effects of extending the Phillips curve estimation to the same sectoral data that we used for the IS curves in Table 2. The model is identical to that used in

¹⁰ Greece, the Irish Republic and Luxembourg had to be excluded through lack of data.

Table 3 but the output gaps are computed for each of the sectors individually rather than for the whole economy.¹¹ For all four sectors the impact on inflation is higher when there is a positive output gap (see Fig. 7). In each case the positive segment coefficient is clearly significantly different from zero. In the case of agriculture and construction the impact is relatively limited. The negative segment coefficients are close to zero and poorly determined, with the exception of services where there is a moderate affect. The sectoral distribution of any excess supply thus has an effect on the overall outcome. Since shocks have differential effects across sectors we would expect this to have differential effects on inflation and hence on monetary policy.

Clearly to quite some extent this is illustrating what we know already as these asymmetric impacts would be picked up by other aspects of macroeconomic models. Sectoral shocks would have differing effects on the exchange rate or import prices for example. Nevertheless these results make it clear that neglecting the distribution of the impact below the EU level could have misleading implications for policy, whether the neglect was national, regional or sectoral. Even within smaller countries the distributional differences still matter.

Our results seem to be a little more robust to the finding of asymmetry and nonlinearity than some other recent studies. In their work on asymmetry and nonlinearity in the Phillips curve, Laxton *et al.*¹² find that while the evidence supports the existence of convex relationships between inflation and unemployment in an expectations augmented specification, the convexity is not strong over the policy relevant range and the evidence relatively weak.¹³ Indeed they conclude (Laxton *et al.* 1997, p.43) ‘standard empirical techniques are not likely to be capable of providing a reliable answer on the functional form’. However, in no case is the convex relationship rejected by the data. They use both the regime change model we employ and a continuous curve and consider the US, UK and Canadian economies. McDonald (1997) and Razzak (1997) find similar relationships for the Australian and New Zealand economies.

One of the difficulties about measuring these relationships is that in practice the observations that we have are ‘policy inclusive’. Over the period governments have sought to stabilise the economic cycle with some combination of monetary and fiscal policy, partly through ‘automatic stabilisers’ and partly through discretionary action on each occasion. Laxton *et al.* (1993) argue that this will tend to reduce our ability to observe the curvature of the relationship. Not only does it inhibit the variance but it reduces the impact of the underlying relation. However, the impact of policy could be even more distorting if policy is itself not symmetric or linear. Economists typically express loss

¹¹ Inflation also relates to the sectoral prices.

¹² Laxton, Rose and Tetlow (1993); Laxton, Meredith and Rose (1995); Clark, Laxton and Rose (1996); Debelle and Laxton (1996); Clark and Laxton (1997); Laxton, Rose and Timbakis (1997)

¹³ The authors use both piecewise linear and curvilinear specifications.

functions in quadratic terms implying that policy will respond more than proportionately as expected outcomes deviate from their targets. However, they tend to make them symmetric (Taylor, 1993). It is perhaps a little more realistic to consider the 'opportunistic' approach to policy (Orphanides and Wilcox, 1996) where 'favourable' outcomes such as more rapid recoveries, balance of payments improvements etc. than expected are accepted and not offset, whereas less favourable outcomes stimulate further policy responses.

Inside the euro area the convexity will have a particular effect if the various member states are out of phase in their economic cycle or have been subject to asymmetric shocks that require structural adjustment that may be slow to come if there is substantial hysteresis in the economy. The economies that are suffering a negative output gap will be doing less to bring inflation down than the economies with the positive output gaps are providing upward pressure. Therefore in general the more asynchronous the euro area turns out to be the tighter monetary policy will need to be compared with any given growth rate for the area as a whole. If cycles are asymmetric in the sense that it tends to be more difficult to get out of recessions then the problem will be exacerbated.

However, it would be mistaken to assume that these effects will be wholly negative. Much of the point of EMU is to change macroeconomic behaviour for the better in the member states. The more rapidly developing economies will be facing looser monetary policy than would have been the case without the union (except for countries that were closely targeting the DM, where there will be rather less change)¹⁴. We can expect, for example, that the countries with the positive output gaps will in fact try to hold down prices more than they would previously out of fear that their competitive position would worsen now that they have no independent exchange rate to offset the worsening in inflation. Indeed there are signs in both Finland and Ireland, which have been growing rather faster than the rest of the euro area that recent growth-inflation combinations have become more favourable. In other words that the sustainable rate of growth has increased and that calculations of the output gap need to be revised (downwards).

At the other end of the spectrum one would expect that the economies having difficulty closing their negative output gaps would also change their behaviour. In this case, they could be expected to try to make their economies more flexible and this is certainly the advice that the ECB is giving (ECB, 2000). These changes will have two effects. In the first place it will tend to reduce the slope of the Phillips curve for countries that find themselves frequently with positive output gaps. It will also tend to increase the sustainable noninflationary rate of growth for both high and low output gap countries. Since one of the characteristics of economic integration is that behaviours are copied,

¹⁴ Although Germany is the largest economy in the euro area and several other economies are closely integrated with it euro monetary policy will itself deviate from what the Bundesbank would have done as the Bundesbank would not have taken into account the consequences for the rest of the area.

even those countries that are not under pressure at either extreme may tend to emulate the others and hence provide a further stimulus to the sustainable noninflationary rate of growth. Furthermore, Issing (1999) has argued that as experience with low inflation continues in the euro area, those setting prices and wages will increasingly form their bargains in the expectation of continuing price stability in the long run. Hence they will not respond aggressively to short-run supply shocks such as the recent rise in oil prices. If such relative price shocks do not spill through into more general inflationary pressure then monetary policy can be somewhat looser.

Thus it is more difficult to judge what will be the aggregate effect of the upward pressure on monetary policy from nonlinearity and the downward effect from changing behaviour. The ECB has the difficult task in setting policy of having to make a judgement about the relative importance of these effects as policy is forward-looking.

5 The Okun Curve in the OECD

These concerns about nonlinearity are not confined to Europe nor to the Phillips curve. Another example is the Okun curve, which has been subject to a number of recent studies (Attfield and Silverstone, 1998; Harris and Silverstone, 1999a, b; Kaufman, 1988; Moosa, 1997, Palley, 1993, Prachowny, 1993 and Weber, 1995, for example). Silverstone and Harris (1999b) find asymmetry of some form for Australia, Japan, New Zealand, the UK, US and West Germany over the period 1978 to 1999. However, the finding is not universal and they cannot reject the null hypothesis of symmetry for Canada over the same period. Perhaps more interesting is the much more detailed treatment of the relationship by Haltiwanger and Schuh (1999), who introduce sector specific factors to help explain the lack of symmetry. We deal with the aggregated relationship first.

The Okun curve (Okun, 1962) is normally expressed as the relationship between the change in unemployment and the percentage change in real output in the economy

$$\Delta U = c_0 + c_1 \Delta Y/Y. \quad (4)$$

However, it is also argued (see Prachowny (1993) for example) that some scaling of the labour variable is required so in our formulation we have also included population of working age, *POP*.¹⁵ The curve may therefore offer some additional insight into the nonlinear operation of the labour market to augment the Phillips curve results of the previous section. Both employment and unemployment appear to respond in an asymmetric manner to demand shocks.

¹⁵ Prachowny (1993) employs a rather more elaborate transformation, incorporating the Okun curve into a production function and considering linear discrepancies of the factors of production from their equilibrium values as well.

We focus on the Harris and Silverstone approach as rather than estimating a curve or piece-wise linear function they build the asymmetry into the error correction mechanism, assuming that there are different correction paths depending upon whether real output is above or below its trend value. In effect, therefore this gives us three different ways of handling the asymmetry. The first, following Kim and Nelson (1999) is to assume that although the function itself is linear, we should treat potential output more in the form of a frontier, very much along the lines of frontier production functions (Aigner *et al.*, 1977; Mayes *et al.*, 1994; Mayes, 1996). This provides a direct extension to Prachowny's (1993) production function basis for the Okun curve. Here the errors in the relationship can be decomposed into a symmetric term e and a non-symmetric term v , which permits a longer tail of values when the economy is operating inside the frontier. Thus in the case of (4) the error term u in the estimated relationship

$$\Delta U = c_0 + c_1 \Delta Y/Y + u \quad (5)$$

would be composed $u = v + e$, with $e \sim N(0, \sigma_e^2)$ and $v \sim M(\mu, \sigma_v^2)$ where M is a nonsymmetric distribution.¹⁶

The second approach, used by Harris and Silverstone (1999*a, b*), is to estimate the cointegrating relationship in (4) and assume that the error correction mechanism ε

$$\varepsilon = U - \hat{U} - \lambda y, \quad (6)$$

where \hat{U} denotes an estimate, can be divided into ε^- where $\varepsilon < 0$ and $\varepsilon^+ \geq 0$. The coefficients on ε^- and ε^+ are then not constrained to be equal in the adjustment process.

Our approach and that of Laxton *et al.* (1997) and Pyhttiä (1999) is to treat the relationship itself as being nonlinear and hence values of the determining variables below 'equilibrium' will have a different impact from those above (see Granger and Teräsvirta (1993) and Tong (1983) for discussions of the estimation of such threshold models)

$$\Delta U = c_0 + c_1 y^+(t) + c_2 y^-(t) + c_3 pop + c_4 \varepsilon_{-1}. \quad (7)$$

In (7) y is the growth rate in GDP, pop the population of working age and ε the error correction term defined in (6) (lagged one period). t is a threshold value for the asymmetry. There are a number of routes to determining this threshold. One would be simply to use a simple form of output gap, although since our data are annual this would entail a fairly trivial definition of potential output, such as the mean rate of growth over the sample period. We show the effects of setting t equal zero so that we distinguish actual recessions from other behaviour and determining the maximum likelihood value for t . In the second case the outcomes tend to be near the mean.

¹⁶ In line with the early frontier production function Kim and Nelson (1999) assume that M is half Normal, Mayes *et al.* (1994) also consider the more general case of a truncated normal.

Each of the three approaches gives a somewhat different flavour to the problem.

In our own work, reported in Table 5 we have used both a longer data series and a wider range of countries from Silverstone and Harris (1999*b*). While we did experiment with a split error correction term it appeared that incorporating the asymmetry into the coefficients of the equation was a rather better determined approach. Different speeds of adjustment alone had lower explanatory power and added little when the output coefficient spilt was already present. In part this may be due simply to the use of annual rather than quarterly data. The Table shows estimates of simple Okun curves for 21 countries from 1961 to 1997.¹⁷

Only in the case of the UK and Japan do we find that there seems to be little relation between output and unemployment when using a linear formulation of (4).¹⁸ However, the relationship for New Zealand is weak (a very different result from that found in Harris and Silverstone, 1999*a*). Once we introduce the asymmetry, most countries produce the positive and negative segments with different slopes and show the expected asymmetry very clearly. If we separate out the data according to whether or not the economy is in recession¹⁹, cols. 1 and 2 in Table 5. In 14 of the 21 cases the coefficients are larger when the growth rate is negative. In other words unemployment rises more when the economy contracts than it falls when the economy expands. This fits with our expectations about hysteresis. However the differences are not in general significant. Of the seven cases that do not conform to this pattern, Finland shows no asymmetry, the US shows the reverse asymmetry but with appropriately signed coefficients, while Greece, Italy and Japan have perversely signed coefficients for the negative segment. However, in each case the likelihood ratio test does not lead us to reject the symmetric relationship. Symmetry is also rejected in the case of the UK but here the negative segment also has a perverse coefficient.

If on the other hand we split the relationship at the point which maximises the likelihood function then only five cases show coefficients where the effect on unemployment is smaller (less negative) below the threshold (cols. 3 and 4 in the Table). Three of the countries from the perverse split at zero and in this group, but the US, Japan and Italy no longer show perversity in this case but Australia and Spain now do. (We were unable to produce estimates for Germany because of the overwhelming effect of unification.) Only in the case of the UK was the coefficient for the negative segment significantly different from zero at the 5% level and here the threshold value, at -0.53% , was very much out of line with the rest of the sample. Most thresholds lay in the range 2.3 to 4.3% and all cases the restriction that the two GDP coefficients be equal was rejected.

¹⁷ Switzerland was eliminated from our initial sample owing to data difficulties in the 1960s.

¹⁸ Moosa (1997) also gets a low value for Japan.

Harris and Silverstone (1999b) also encounter the problem of perversity but only a limited scale and their estimates are well determined. They find that Canada does not show asymmetry, New Zealand, the US and Germany show no adjustment when the error correction term is negative - and hence clear asymmetry – while Australia and Japan have larger effects for the negative segment, i.e. reverse asymmetry. They do not suffer from unexpected signs. Thus their more limited sample demonstrates asymmetry on a rather similar scale to our own but with somewhat different country characteristics. The differences may simply reflect that the asymmetric process investigated is not the same.

However, use of these aggregate models in some senses only provides a description of the stylised facts and not an explanation of why the asymmetry may be occurring. This becomes clearer at the disaggregated level. In discussing regional disaggregation of the Phillips curve we suggested that it was the tightest labour markets that contributed to inflation and hence that we needed to consider the spread of unemployment across markets and not just the level in order to understand the nature of the problem. In the case of the Okun curve Haltiwanger and Schuh (1999) demonstrate that it is necessary to understand the dynamics of the labour market at the plant level to get an appreciation of asymmetry.

They show that a further term should be added to our formulation of the Okun curve, used in Table 5, which reflects the degree of ‘job reallocation’²⁰ both within and between sectors. For all of the five different measures they use there is a clearly significantly positive effect on unemployment from increased rates of job reallocation. However, Haltiwanger and Schuh (1999) go even further and estimate determinants of job reallocation. Here not surprisingly it is downturns in the overall economy that help, including the lagged influence of monetary policy. Relative price shocks also provide an explanation so supply as well as demand shocks have a role to play. The problem also shows considerable persistence. Thus in downturns unemployment is more than symmetrically large than in upturns and takes longer to fall than it did to rise.

6 Conclusion

We have argued that there are clear asymmetries in the relationship between demand pressure and inflation in the European union and the euro area in particular. These asymmetries exist at the sectoral and regional levels as well. As a result, using arithmetic weights to add effects across countries in order to determine area wide monetary policy could produce erroneous results. This is exacerbated by the fact that there is considerable variation across the EU countries in their responses.

¹⁹ I.e. if GDP falls.

²⁰ We describe this as ‘churning’ in Mayes (1996).

It therefore matters which part of the area is experiencing which shocks. Average values can be misleading. However, if business cycles among the EU countries are becoming relatively coordinated, as Artis *et al.* (1999) indicate, then the problem is reduced.²¹ It will then be differences in the speed and extent of the transition mechanism within countries that matter rather than differences according to where they are in the cycle as well. It still will not disappear for if the main problems lie in countries such as Spain where the impact of disinflationary policy is slower and milder than in many other countries

We primarily focus on asymmetries stemming from the behaviour of the labour market. Rapid downturns in the economy appear to have more than proportionate downward effects on unemployment, partly because of mismatch between the sectors and regions where the jobs and unemployed lie. This effect is likely to be greater in the EU where labour mobility is lower than the US where the phenomenon is already clear. A slower response to adverse shocks makes recovery phases longer and unemployment persistent.

However, these forms of asymmetry have a rather different impact on the inflationary process. The straightforward asymmetry, inherent in the convexity of the Phillips curve, is that excess demand in product or labour markets has a significant upward effect on inflation while deficient demand has little or no effect on lowering inflation. The process is however more complex as the dynamics suggest that big differences between sectors and regions distort the picture. It is the existence of tightness in parts of the labour market that affects overall inflation and average unemployment and by analogy probably tightness in sectors of the product market that tends to intensify the inflationary pressure. Thus our findings indicate that in each example we have considered, ignoring the disaggregated problem will tend to result in misleading policy conclusions.

The asymmetry is not restricted to demand shocks as supply shocks, particularly through the exchange rate and foreign sector can have sharply differing impacts both across the member states of the EU and across the sectors of industry. The traditional implication for policy set out in Laxton *et al.* (1995) is that monetary policy will need to be set somewhat more restrictively than is implied by linear symmetric models. However, it is also likely that any 'new economy' effects (ref) where faster non-inflationary and higher unemployment growth develops will occur in the areas of high demand and relative labour shortage. Hence the implications of the asymmetric effects, observed in data from the past may need to be rethought if major sectors in the economy are undergoing structural change in their responsiveness and flexibility.

²¹ However, Artis *et al.* (1999) also find discrepancies in behaviour between recoveries and recessions. For example, Spain has a weak and slow response to recessionary forces compared to its partners but a stronger one than the average with respect to booms.

Table 1 OLS estimation results for the 1987:1–1997:4 period

Name lags	∇y_{t-1}	∇y_{t-2}	rr_{t-k}	re_{t-k}	$oecd_{t-k}$	R^2 (SEE)	DW	λ
Austria 2,2,2	.729 (6.39)	-.095 (0.74)	-.021 (0.91)	.009 (0.65)	.338 (0.65)	.660 (0.58)	1.90	2.4
Belgium 4,3,2	1.145 (6.60)	-.457 (2.85)	-.046 (1.28)	.001 (0.08)	.334 (1.55)	.882 (0.40)	1.81	41.7
Denmark 1,3,1	.105 (1.02)		-.152 (1.77)	.018 (1.51)	.065 (1.12)	.261 (0.84)	1.96	8.3
Finland 3,2,2	.773 (5.36)	-.158 (1.00)	-.152 (2.36)	.048 (3.90)	.406 (0.83)	.881 (1.19)	1.99	3.1
France 4,2,2	.960 (6.64)	-.274 (1.56)	-.069 (2.06)	.027 (1.99)	.305 (1.35)	.871 (0.44)	1.94	2.5
Germany 7,3,2	.545 (2.73)	.181 (1.23)	-.072 (0.87)	.020 (0.84)	.123 (0.57)	.911 (0.81)	1.53	3.6
Ireland 1,3,2	.970 (7.18)	-.298 (2.63)	-.056 (1.73)	.028 (1.56)	.788 (3.09)	.867 (0.72)	1.81	2.0
Italy 3,2,1	.701 (8.88)		-.095 (1.90)	.012 (1.43)	.332 (2.35)	.767 (0.50)	1.97	7.8
Neths 1,2,2	1.077 (11.41)	-.381 (4.72)	-.037 (1.53)	.016 (1.76)	.259 (2.34)	.824 (0.39)	1.86	2.3
Port 3,1,1	.447 (3.47)	.135 (1.30)	-.081 (2.87)	.007 (1.24)	.747 (3.74)	.901 (0.48)	1.95	11.6
Spain 1,2,1	1.518 (15.98)	-.595 (6.53)	-.008 (1.16)	.009 (3.01)	.115 (1.85)	.982 (0.18)	1.44	0.8
Sweden 1,2,2	.537 (5.21)	.226 (1.70)	-.065 (5.21)	.052 (4.05)	.604 (2.30)	.809 (0.77)	2.33	1.2
UK 1,1,1	.981 (10.50)	-.175 (1.86)	-.033 (1.84)	.022 (2.96)	.262 (4.34)	.950 (0.40)	1.83	1.5

The dependent variable ∇y is the output gap constructed by the HP filter. rr is the real interest rate, re the real exchange rate with respect to US dollar. $oecd$ denotes the output gap for OECD GDP. λ is the ratio between interest rate and exchange rate elasticities. Lags indicate the lag length for rr , re , $oecd$ (in this order), respectively. The data are quarterly and cover the period 1987:1–1997:4. For the UK, the US output gap is used instead of the OECD output gap. The German equation includes a level and one period dummies for the unification period (1991:1–1997:4). All estimates are OLS estimates.

Table 2 Estimates of an IS curve with panel data

	$\nabla y(-1)$	re(-2)	rr(-2)	oecd(-1)	R2/SEE/DW	λ
EMU10	.833 (26.76)	.012 (3.47)	-.039 (2.43)	.334 (4.36)	.781/.699/2.06	3.3
EU11	.823 (25.98)	.014 (4.04)	-.037 (3.14)	.250 (3.29)	.759/.727/2.17	2.6
EU13	.812 (29.37)	.012 (3.85)	-.039 (3.58)	.301 (4.45)	.760/.721/2.04	3.3
EU13:GLS	.838 (40.57)	.012 (4.81)	-.023 (2.18)	.273 (5.04)	.803/.718/2.08	1.9
EU13:SUR	.812 (35.70)	.011 (4.28)	-.012 (1.34)	.265 (4.28)	.757/.725/2.02	1.1
Agriculture	.347 (3.90)	.010 (0.42)	-.010 (0.13)	.649 (1.32)	.152/4.532/1.77	1.0
Industry	.701 (19.08)	.026 (3.78)	-.056 (2.25)	.643 (4.37)	.658/1.444/2.17	2.2
Construction	.671 (11.55)	.005 (0.40)	-.089 (1.52)	1.017 (3.39)	.525/2.785/2.35	18
Services	.828 (24.80)	.006 (1.80)	-.028 (1.66)	.191 (2.69)	.703/.670/2.25	4.7

All estimates (except for EU 13 countries) are LS estimates. The dependent variable is ∇y_t , all variables are defined as in Table 1. The pooled cross-country data consist of observations for 1987.1-1997.4. GLS denotes Generalised Least Squares estimates, which use cross section weights to account for (cross-section) heteroscedasticity. SUR denotes Seemingly Unrelated Regression estimates. The standard errors are heteroscedasticity consistent. The number of observations is 442 for EMU 10, 484 for EU 11 and 576 for EU 13. With sectoral data, the number of observations is 483. The set of countries in this case is: Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdom. Numbers inside parentheses are t-ratios except the Standard Errors of Regression

Table 3 Estimates of a nonlinear Phillips curve

	$\Delta p(-1)$	$\Delta p(-2)$	Δm	$\Delta m(-1)$	$\nabla y(-)$	$\nabla y(+)$	R2/SEE/DW
SUR	.353 (14.25)	.377 (16.21)	.070 (10.86)	.024 (3.70)	.038 (3.90)	.038 (3.90)	F(y=-y+) .663/.692/2.02
--							Constrained =
OLS	.304 (8.98)	.405 (12.52)	.076 (7.32)	.036 (3.67)	.019 (0.79)	.068 (2.71)	.667/.690/1.97
H=0							.230
GLS	.375 (11.81)	.397 (13.58)	.072 (10.77)	.020 (3.26)	.007 (0.44)	.066 (3.45)	.662/.694/2.08
H=0							.044
SUR	.350 (14.12)	.376 (16.18)	.070 (10.86)	.025 (3.76)	-.002 (0.11)	.076 (3.98)	.664/.692/2.03
H=0							.012
SUR	.350 (14.12)	.375 (16.16)	.070 (10.88)	.025 (3.75)	-.001 (0.05)	.075 (4.09)	.664/.692/2.03
H=-.005							.010
SUR	.288 (8.30)	.259 (7.26)	.064 (6.81)	.017 (1.97)	.027 (1.31)	.090 (4.25)	.580/336/2.00
H=O, (1)							.000
SUR	.284 (8.04)	.274 (7.56)	.060 (6.21)	.016 (1.81)	.005 (1.09)	.020 (3.36)	.570/.543/1.93
H=O, (1) a							.027
SUR	.271 (6.66)	.261 (5.70)	.056 (5.71)	.014 (1.59)	-.005 (0.38)	.067 (4.30)	.576/340/1.30
H=O, (1) i							.002
SUR	.293 (8.08)	.258 (7.07)	.060 (6.08)	.009 (2.03)	_.010 (1.34)	.031 (3.91)	.590/332/1.93
H=O, (1) c							.002
SUR	.285 (8.17)	.269 (7.56)	.067 (7.09)	.018 (2.08)	.047 (1.79)	.077 (3.09)	.575/.539/1.98
H=O, (1) s							.005

The data cover the period 1975:4-1998:4. The number of observations is 1,176. P denotes consumer prices, m import prices and y the HP residual of GDR F(y=-y+) denotes probability of the F test statistics for the hypothesis that the coefficients of y(-) and y(+) are equal (in the first equation the coefficients are constrained equal).

(1) The data cover the period 1987:1-1998:4 only. (a/i/c/s) The output gap for agriculture/industry/construction/services is used for ∇y instead of the aggregate measure. .

Table 4 **Estimates of the Phillips curve with regional EU data**

	(1)	(2)	(3)	(4)	(5)	(6)
Δp_e	.655 (12.42)	.649 (10.17)	.513 (12.72)	.488 (11.77)		.534 (12.83)
$\Delta p(-1)$.254 (5.72)	.214 (3.92)	.191 (5.26)	.143 (3.66)	.567 (23.89)	.175 (4.73)
Δm	.058 (6.56)	.056 (5.43)	.063 (10.14)	.068 (9.25)	.085 (13.19)	.063 (10.48)
U	-.053 (3.36)	-.003 (0.23)	-.256 (10.06)	-.248 (12.84)	-.290 (11.82)	-.195/-.235 (5.97/8.87)
U _{max} - U _{min}	.068 (4.81)		.147 (6.47)		.154 (6.86)	.148 (6.83)
Usd		.103 (2.32)		.192 (2.93)		
T	-.016 (1.82)	-.001 (0.45)	-.112 (10.06)	-.108 (9.05)	-.112 (9.25)	-.112 (10.57)
R ²	.868	.866	.914	.918	.885	.915
SEE	.963	1.073	.816	.878	.938	.811
DW	1.526	1.289	1.800	1.590	1.928	1.805
Dummies	No	No	yes	yes	Yes	Yes
Obs	153	143	153	143	153	153

All estimates are SUR estimates. Δp_e denotes expected inflation (OECD forecasts), m import prices, P consumption prices, U the aggregate unemployment rate, U_{max} - U_{min} the dispersion of regional unemployment rates, Usd the corresponding standard deviation and t time trend. Equation (6) is estimated using a threshold model specification and allowing the coefficient of the unemployment rate to vary depending on whether the rate is below (first coefficient) or above 8% (second coefficient) per cent threshold. The hypothesis that the coefficients are equal can be rejected with marginal probability of 0.002 using the F test.

Table 5. Estimates of a nonlinear Okun curve

	$y^+(0)$	$y^-(0)$	$y^+(c)$	$y^-(c)$	F
Australia	-.021 (4.04)	-.049 (0.41)	-.045 (3.42)	-.002 (0.09)	10.26
Austria	-.039 (3.76)	-.512 (-.047)	-.050 (5.03)	-.075 (3.93)	14.53
Belgium	-.026 (2.33)	-.125 (2.85)	-.038 (4.42)	-.070 (4.66)	18.29
Canada	-.038 (4.22)	-.068 (2.62)	-.040 (5.78)	-.071 (4.93)	15.23
Denmark	-.022 (1.03)	-.451 (3.36)	-.030 (1.48)	-.392 (3.52)	18.45
Finland	-.071 (5.29)	-.070 (3.07)	-.066 (6.15)	-.079 (6.28)	16.82
France	-.019 (1.15)	-.050 (0.43)	-.028 (2.00)	-.080 (2.48)	15.75
Germany	-.096 (4.56)	-.135 (0.93)	–	–	–
Greece	-.023 (3.03)	.024 (0.67)	-.027 (3.58)	.038 (1.19)	21.67
Iceland	-.072 (4.84)	-.119 (2.81)	-.076 (5.76)	-.121 (3.35)	15.67
Ireland	-.019 (2.17)	-.088 (0.35)	-.025 (3.31)	-.050 (2.86)	5.20
Italy	-.026 (2.27)	.021 (0.34)	-.019 (1.81)	-.043 (2.82)	14.05
Japan	-.007 (1.16)	.013 (0.18)	-.008 (1.35)	-.020 (2.02)	10.33
Netherlands	-.023 (0.95)	-.182 (1.22)	-.048 (2.73)	-.123 (4.07)	112.86
New Zealand	-.075 (1.21)	-.036 (0.22)	-.086 (1.78)	.025 (0.33)	24.38
Norway	-.043 (2.14)	-.185 (0.49)	-.059 (3.00)	-.094 (2.95)	6.79
Portugal	-.044 (2.47)	-.250 (0.71)	-.055 (3.19)	-.094 (3.60)	16.11
Spain	-.019 (3.49)	-.062 (0.79)	-.026 (5.09)	-.013 (1.61)	29.24
Sweden	-.064 (2.72)	-.122 (1.92)	-.062 (3.65)	-.110 (5.05)	13.11
UK	-.032 (1.50)	.095 (1.83)	-.031 (1.51)	.102 (1.97)	21.08
USA	-.067 (7.39)	-.036 (0.98)	-.061 (9.57)	-.081 (5.24)	9.39

Numbers inside parentheses are t-ratios $y^+(0)$ and $y^-(0)$ denote estimates with zero threshold and $y^+(c)$ and $y^-(c)$ estimates with nonzero (estimated) threshold value. The parameters are derived from the following estimating equation $\Delta u_t = a_0 + a_1 \Delta y_t^+ + a_2 \Delta y_t^- + a_3 \Delta \text{pop}_t + a_4 \text{EC}_{t-1} + e_t$, where u denotes the (log) number of unemployed, y the growth rate of output, pop the (log) working-age population, EC an error-correction term in terms of u , pop and time trend and e the error term. In the nonlinear case, y is replaced by y^+ and y^- so that y^+ corresponds to positive values of y and y^- of negative values. F is the F(1,31) test for the equality of the coefficients of y^+ and y^- in the case of nonzero threshold. Estimates are based on annual OECD data for 1961–1997.

Fig. 1 Confidence intervals of MCI weights

P10 = EMU, P13 = EU, SC = single countries
 LS = least squares, GLS = generalised least squares,
 SUR = seemingly unrelated regression estimates

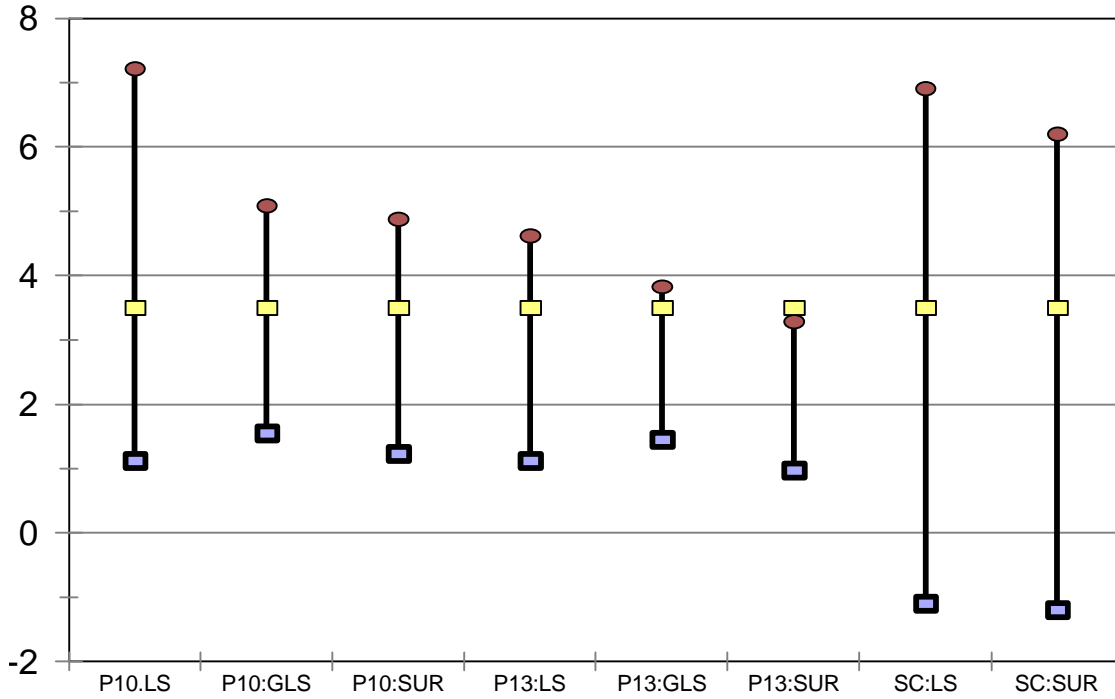


Figure 2. Values of MCI parameter for different sectors

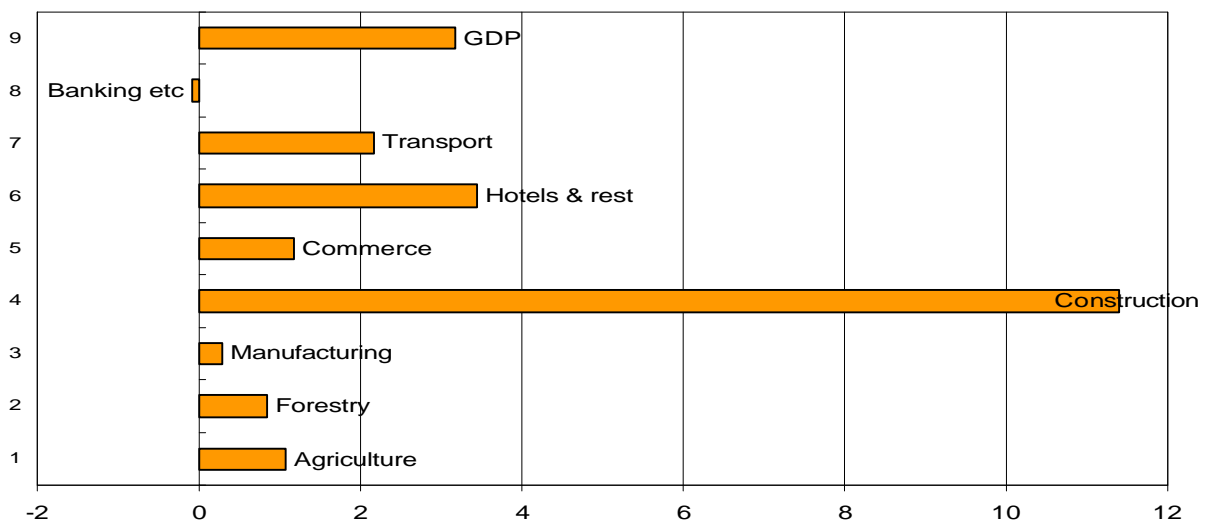


Fig. 3 Sectoral and panel estimates of MCI ratios for the EU

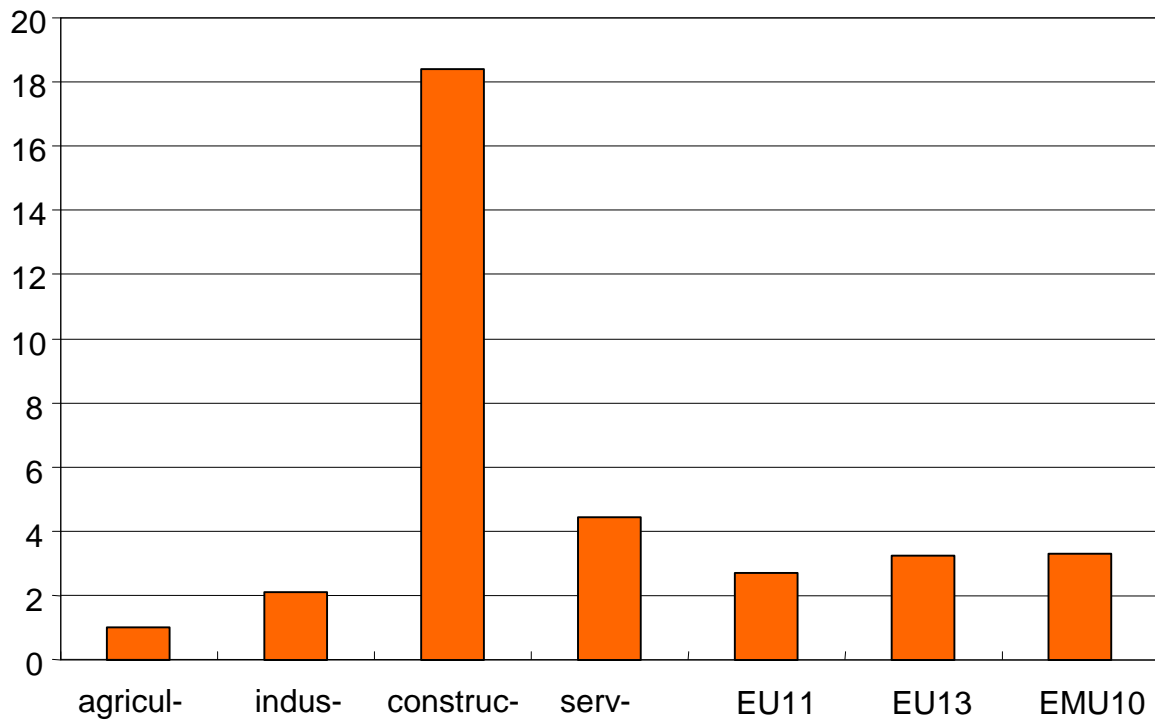


Fig.4 Estimates of simple nonlinear Phillips curve for the EU

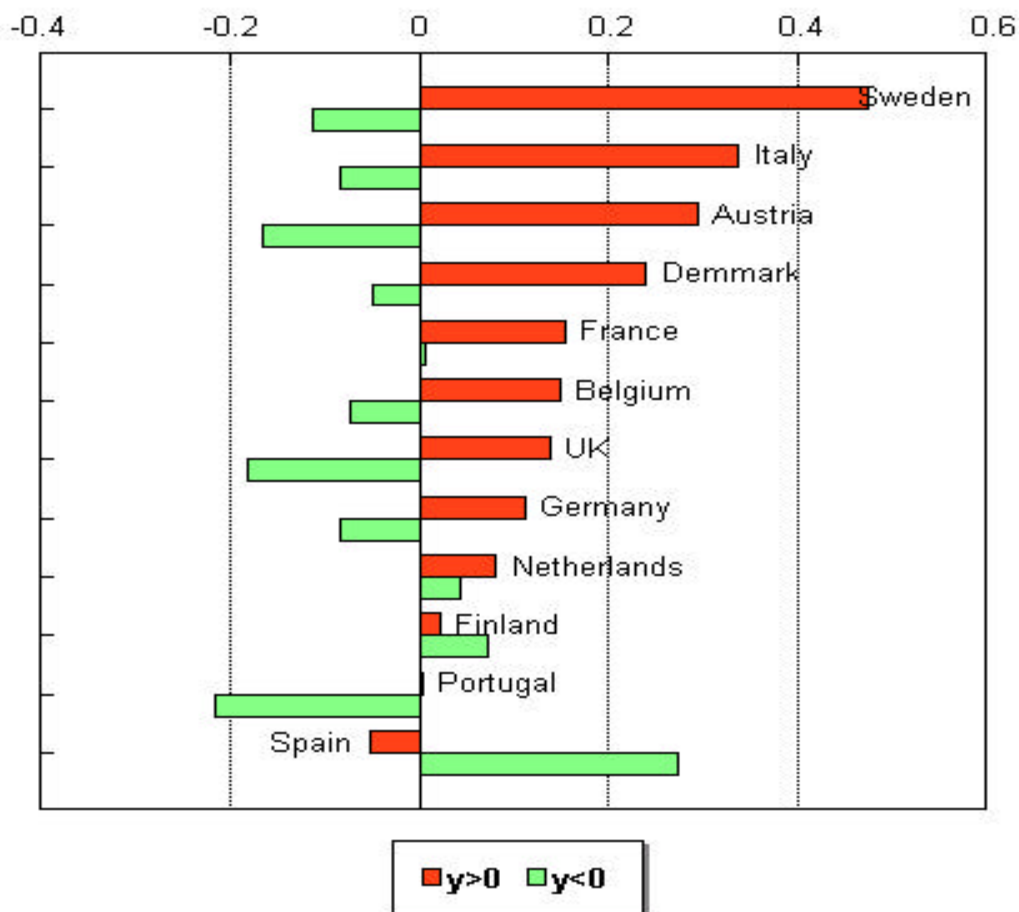


Fig. 5 **Linearity and nonlinearity in the Phillips curve and the setting of policy**

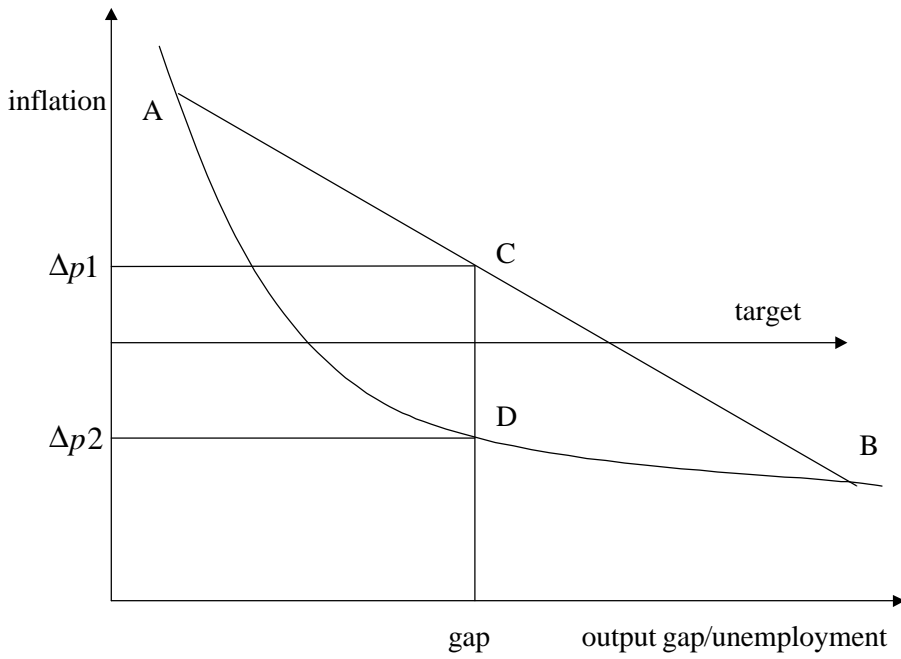
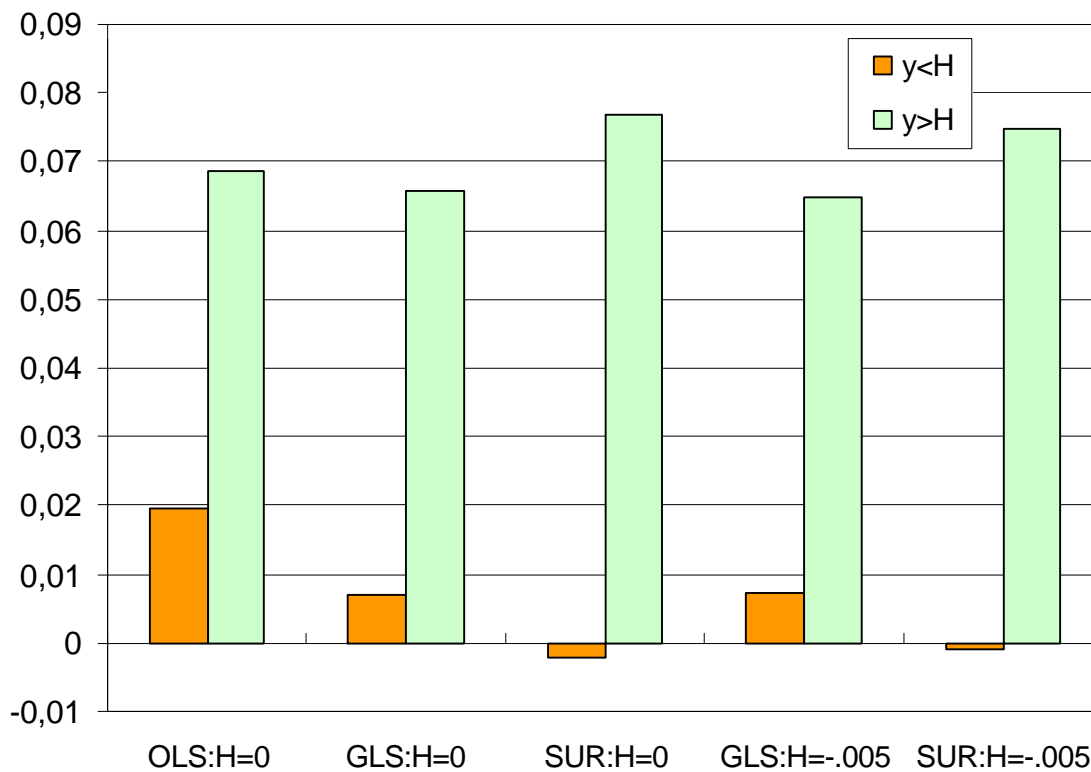
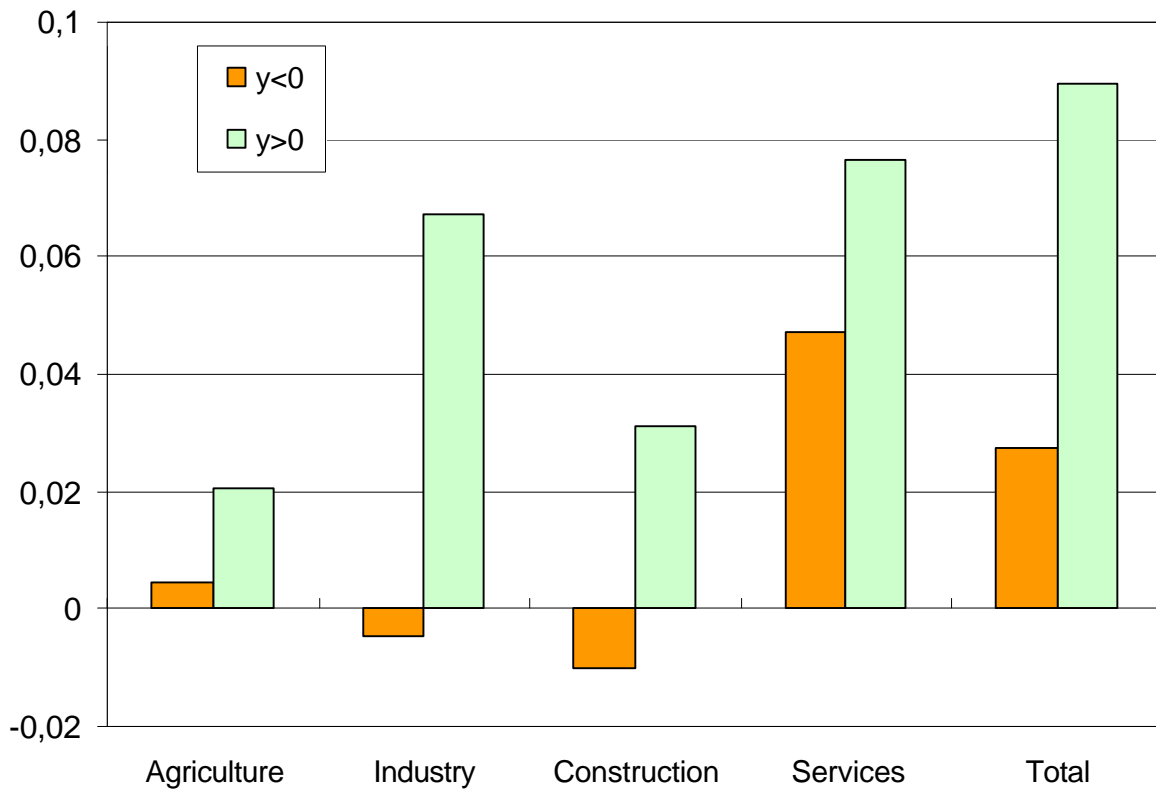


Fig. 6 **Output gap coefficients in piecewise linear Phillips curve for the EU**



Panel data as in Table 3. OLS, GLS and SUR defined as in Fig.1. H denotes level of output gap at which the split takes place.

Fig. 7 Output gap coefficients from the piecewise linear Phillips Curve using sectoral data



Notes as for Fig 6.

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