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The use of real-time information in Phillips curve relationships for the euro area

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Abstract:

The dynamics of the Phillips Curve in New Keynesian, Expectations Augmented and Hybrid forms are extremely sensitive to the choice, timing and restrictions on variables. An important element of the debate revolves round what information decision-makers took into account at the time and round what they thought was going to happen in the future. The original debate was conducted using up to date, revised estimates of the data as in the most recent official publications. In this paper, however, we explore how much three aspects of the specification of the information available at the time affect the performance of the various Phillips curves and the choice of the most appropriate dynamic structures. First we consider the performance of forecasts, published at the time, as representations of expectations. Second, we explore the impact of using 'real time data' in the sense of what were the most recently available estimates of the then present and past. Finally we review whether it helps to use the information that was available at the time in the choice of instruments in the estimation of the relationships rather than the most up to date estimate of the data series that has been published. Thus different datasets are required in the instrument set for every time period. We use a single consistent source for 'real-time' data on the past, estimates of the present and forecasts, from OECD *Economic Outlook* and *National Accounts*. We set this up as a panel for the euro area countries covering the period since 1977. The OECD publishes forecasts twice a year, which permits a more detailed exploration of the importance of the timing of information. Our principal conclusions are (1) that the most important use of real time information in the estimation of the Phillips curve is in using forecasts made at the time to represent expectations; (2) real time data indicate that the balance of expectations formation was more forward than backward-looking; (3) by contrast using the most recent, revised, data suggests more backward-looking and less well-determined behaviour.

Keywords: real-time data, Phillips curve, euro area

JEL-Classification: E31

Non Technical Summary

We consider three aspects of how using only information available at the time, commonly called 'real time data', helps improve the explanation of inflation in the euro area countries over the period 1977 to 2002. These three aspects are: using forecasts, published at the time by the OECD as a measure of what people expected to happen in the future; using the information published at the time instead of the most recently revised data available today; using only other information available at the time to help improve the process of estimation and not including information that has come to light since. We use the best known representation of the inflationary process, known as the Phillips curve to explore these aspects of the use of real time data and consider three widely used versions that incorporate different views of how people use forward-looking information: the Expectations Augmented, New Keynesian and Hybrid models. We find that using real time data shows that people were much more forward-looking than previously thought from using the most up to date revised data. Forward-looking concerns are more important than backward-looking ones in all forms of the model. Using OECD forecasts works well as a representation of what people expected and avoids some of the perverse results of other forward-looking approaches to how expectations are formed. In general real time data seem to offer a closer and more plausible explanation of inflation than the most recent information. There are, however, problems with deriving real time measures of the pressure of demand. Using the estimates made by OECD at the time does not work very well. Using other real time information to improve the estimation does not seem particularly important. The results confirm earlier work on the United States.

Nicht technische Zusammenfassung

Wir betrachten drei Möglichkeiten, wie die Inflation in den Euro-Ländern zwischen 1977 und 2002 anhand der ausschließlichen Verwendung so genannter Echtzeit-Daten, d. h. Informationen, die zum jeweiligen Zeitpunkt zur Verfügung standen, besser erklärt werden kann. Bei diesen drei Möglichkeiten handelt es sich erstens um die Verwendung von Prognosen, die zum jeweiligen Zeitpunkt von der OECD veröffentlicht wurden und die als Messgröße für die Erwartungen der Bevölkerung gesehen werden, zweitens die Verwendung von Echtzeit-Informationen anstelle der heute zur Verfügung stehenden revidierten Daten und drittens die ausschließliche Verwendung anderer zum jeweiligen Zeitpunkt verfügbarer Informationen, um die Schätzung zu optimieren – ohne Informationen, die seither verfügbar geworden sind. Wir bedienen uns der geläufigsten Darstellung des inflatorischen Prozesses, der so genannten Phillips-Kurve, um diese drei Möglichkeiten der Verwendung von Echtzeit-Daten zu untersuchen. Wir betrachten drei sehr gebräuchliche Varianten, die sich darin unterscheiden, wie in die Zukunft gerichtete Erwartungen durch die Bevölkerung integriert werden: die um Erwartungen erweiterte Phillips-Kurve, das neukeynesianische Modell und Hybrid-Modelle. Bei Verwendung von Echtzeit-Daten kommen wir zum Schluß, dass die Bevölkerung viel vorausschauender ist, als dies auf der Basis revidierter Daten zu sein schien. Überlegungen hinsichtlich der zukünftigen Entwicklung spielen bei allen Varianten des Modells eine gewichtigere Rolle als solche bezüglich der Vergangenheit. OECD-Prognosen eignen sich gut für die Darstellung der Erwartungen und vermeiden einige der verzerrten Ergebnisse bei anderen Ansätzen zur Erwartungsbildung. Im Allgemeinen scheint die Inflation genauer und plausibler mit Echtzeit-Daten erklärt werden zu können als mit revidierten Daten. Allerdings ist die Ableitung des Nachfragedrucks mit Hilfe von Echtzeit-Daten mit Problemen behaftet. Die von der OECD zum betreffenden Zeitpunkt vorgenommenen Schätzungen sind nicht sehr hilfreich. Die Verwendung anderer Echtzeit-Informationen zur Verbesserung der Schätzung scheint nicht besonders bedeutsam. Die Ergebnisse bestätigen frühere Untersuchungen zu den Vereinigten Staaten.

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1 Introduction

One of the problems in the analysis of economic relationships is that it is necessary to explain people's behaviour in the context of what they knew and believed at the time. This is particularly clear in the case of policy decisions, as has been illustrated by Orphanides (2001) for the United States and Huang *et al*. (2001) for New Zealand, inter alia. With the benefit of hindsight, it can be difficult to understand how some large policy errors could have been made. Once data available at the time (real time data) are used in regressions then explanation of the decisions improves. Using data that takes into account all the subsequent revisions and improvements may give a better representation of what was actually happening at the time but it is not necessarily as good an estimate of what people thought was the case at the time.

Decision-makers, of course, know that the information they face is imperfect and they take steps to go beyond the published statistics in building a view.[1] Hence, just as using the most recently revised data may not be an appropriate description of what people believed at the time, so also may the version of the data available at the time not be an accurate description of beliefs. Most relevant decisions are forward-looking, so the discussion extends beyond the simple concern over what was published. We, therefore, use estimates published at the time (by the OECD) as our real time data, rather than just the first estimates published by the statistical authorities after the event, as these take a wider set of information into account.[2]

* Bank of Finland, PO Box 160, 00101 Helsinki, Finland. Tel: +358 9 183 2569, email: david.mayes@bof.fi, maritta.paloviita@bof.fi. The views expressed in this paper are our own and may not necessarily reflect any that may be held by the Bank of Finland. Thanks are due to Heli Tikkunen who undertook the laborious job of compiling the database. Fortunately all the back issues of both *Economic Outlook* and *National Accounts* could be found in the Bank of Finland's archives. With the kind permission of the OECD our database is available from xxxxxxxx. We are grateful to Athanasios Orphanides, Pierre Siklos and participants in the conference on 'Real Time Data and Monetary Policy' at the Bundesbank, Eltville in May 2004 for constructive comments.

1 See Coats *et al.* (2003) for a recent example.

2 It is easy to regard the official statistics as being 'data' while referring to other people's views as being 'estimates'. Macroeconomic 'data', whether official or not, are still the result of estimation and not direct observation. Official estimates are subject to revision as more information comes to light,

Addressing this problem is particularly important if we are trying to describe expectations, as these are not directly observable. Expectations are rooted in the information set available at the time. Hence it is worth exploring whether the most recent estimates or real time data act as a better explanation. Expectations and forecasts are closely related. Indeed if the forecast being discussed is the estimate of the mean value of the distribution of possible outcomes then the concepts are similar. Moreover, if, like the estimates described in the previous paragraph, they are simply an attempt to predict the statistical authority's estimates then they should be quite a close conceptual match.

The key distinction is that forecasts can be observed. Hence they are potentially a proxy for expectations. They are also a real time source of information in that a stream of them is available for the main variables in the economy. Unfortunately, they have a number of drawbacks. First of all, only some forecasts are published. Secondly, each forecasting group uses a different basis for its forecast – most are highly conditional, some implausibly so in using unchanged settings for monetary policy (Mayes and Tarkka, 2002). Thus not only does each forecast only represent what a particular group claims to think, these numbers are often not estimates of the expected value even though they are forward-looking. At the very least, it is clear that some forecasters are considering the mode rather than the mean. The Bank of England, for example, explicitly considers the difference between the two in setting out the plausible distribution of outcomes.[3]

Published forecasts are thus not necessarily very representative of what people were thinking at the time and may not be a very good estimator of expectations, even if we combine forecasts from a number of sources. Such combinations can be the published Consensus Forecasts or statistical combinations of the information along the

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especially if series become implausibly uneven or inconsistent with estimates of other related variables. Outside estimates tend to make much more use of economic models than do those produced by the official statisticians, who place more weight on aggregating detailed estimates of components of the macroeconomic variable. Although we use a common OECD source, *Economic Outlook*, for building up our information on what was believed at the time about the past, current and future values of output and inflation, the methods used by the OECD for producing these three categories of estimates are different. Estimates of the past are largely harmonised combinations from official statistical agencies, whereas estimates of the current and future periods employ the normal range of forecasting techniques, which vary depending on the time horizon from the latest period for which the most recent official estimates are available.

[3] Novo and Pinheiro (2003) discuss this issue in some detail.

lines of Stock and Watson (1999). It is clearly debatable how they perform relative to other estimators, all of which have their drawbacks. It is, for example, possible to use surveys of opinion in some cases. Their validity depends on how representative the sample is and how well people are able to describe their position on the particular topic.[4]

In this paper we seek to use both sorts of 'real time data' that we have discussed – the estimates available at the time and published forecasts. We extend this realism as far as possible by using the most recent vintage of the historical series of the variables that was available at the time as well. We pick all of these, historical data, estimates of the current period and forecasts from the same source, the OECD. All this is in the context of estimating forward-looking Phillips curves that require estimates of expectations involving more than just lagged information.[5] However, the process of estimation throws up a further difficulty, as we should normally consider the use of GMM or some other method of handling simultaneous determination of the explanatory variables in the relationship. To achieve the necessary identification we should use a set of variables that give a good explanation of the explanatory variables but are not themselves correlated with the error term in the equation.[6] Such variables should be 'predetermined' but does this mean that they should have been 'known at the time' i.e. real time data? One of the problems here is consistency. If we are using real time data for the explanation in the model then should the instruments themselves also be of precisely the same vintage of publication/knowledge? This introduces a further quirk in estimation. It is common to use lagged variables as instruments but the real time lagged variable is not the lag of the real time variable. In other words it is this period's 'published' estimate of the previous period(s) that is appropriate. The estimate made last period of the then current value will have been revised, along with estimates of earlier periods. Maybe this

[4] It is not really possible to get any other series of forecasts of a similar length from a different source (Gerlach, 2004). Consensus Economics now produce suitable forecasts for much of the euro area but prior to 1995, inflation data relate only to France, Germany and Italy, which is insufficient for our purpose. The results in Gerlach (2004) suggest that the aggregated Consensus Economics estimates for the euro area perform noticeably worse than the OECD estimates we have used for inflation.

[5] One of the other attractions of picking on the Phillips curve is simply that quite a lot of work has been done on it already using real time data from a number of countries: Gruen *et al.* (2002) and Robinson *et al.* (2003) for Australia, for example; extensive work by Orphanides and colleagues on the US, of which Orphanides and van Norden (2003) is a recent example; Neiss and Nelson (2002) consider both of these countries and the UK.

last issue is of second order importance but the answer is not clear without looking. It is clearly dependent on both the extent of revision of the data series and on the model being estimated. Thus the compilation of the instrument data set will require using all of the vintages of data in the same sort of way that is required for the real time data itself.

In the sections which follow we therefore look at each of these three issues in turn: the use of real time information in the form of forecasts to act as an estimator of expectations, the use of real time data in the sense of the information available at the time and last, the use of real time instruments. We begin however with outlining our particular application, namely the Phillips curve and the datasets relating to the euro area countries that we employ.

2 The Phillips curve

Here we explore the case of the Phillips curve, in part because it provides a good illustration of all the issues we raise and also because it has been subject to real time investigation already so there is other evidence to draw on.[7] It is one of the best known macroeconomic relationships in which expectations (of inflation in this instance) have a key role to play. Indeed it is differences in the nature of expectations that forms one of the key factors differentiating the specifications that are most under contention in the literature at present, the Expectations Augmented and New Keynesian Phillips curves. However, it has the further advantage that a common feature of many versions of both specifications uses an output gap as an explanatory variable. That is also an unobservable variable that needs to be estimated. Many measures of output gaps suffer from the 'end point' problem, which makes the role of real time data even more important, as it tends to be the most recent observations that are changed the most. It is only well after the event that we can form a clear view of whether the trend from which the gap is measured has itself changed. In the short-run there is considerable scope for confusing gaps with changes in trend.

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[6] One way of looking at this (Rudd and Whelan, 2001) is that they should not simply be 'omitted variables' from the proper explanation.

[7] On a more prosaic level we picked it because we have been considering various aspects of the Phillips curve in the euro area countries for some time and it was a natural extension of the work (Paloviita and Mayes, 2003; Mayes and Virén, 2002; Pyyhtiä, 1999, for example).

A common approach to trying to explore the importance of the timing of knowledge and information in the Phillips curve is to begin by expressing the Expectations Augmented and New Keynesian models in as similar a form as possible. Thus we can use:

$$\pi_t = \mathrm{E}_{t-1}\{\pi_t\} + \lambda \hat{y}_t \qquad (1)$$

for the Expectations Augmented specification, where E_{t-1} is the expectations operator conditional on information available in period t–1, π_t denotes the period t inflation rate, defined as the rate of change of prices from period t–1 to period t, the term $\hat{y}_t$ denotes the period t excess demand. In the same way we can write:

$$\pi_t = \beta \mathrm{E}_t\{\pi_{t+1}\} + \kappa \hat{y}_t, \qquad (2)$$

for the New Keynesian relationship, where $\kappa = \lambda\delta$. The extra complexity in the latter case occurs because excess demand is not the correct measure for the forcing variable but a proxy for real marginal cost. Thus, the original New Keynesian specification is:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k \mathrm{E}_t\{mc_{t+k}\}, \qquad (3)$$

as inflation is equal to the discounted stream of future real marginal costs, *mc*. In empirical studies, the output gap is a commonly used proxy for the real marginal costs, but labour costs have also been used (Galí and Gertler, 1999; Sbordone, 2002). These variables are assumed to capture changes in real marginal costs associated with variation in excess demand in the economy. Under certain assumptions about technology, preferences and the structure of labour markets we can link the output to real marginal costs within a local neighbourhood of the steady state of log real marginal costs according to:

$$mc_t = \delta \hat{y}_t, \qquad (4)$$

see, for example, Fuhrer and Moore (1995) and Roberts (1998).

Lastly, there has also been some work on Hybrid models that incorporate features of both the Expectations Augmented and New Keynesian approaches (Galí and Gertler,

1999, for example). A simple version that incorporates forward-looking and backward-looking elements is

$$\pi_t = \theta \mathrm{E}_t\{\pi_{t+1}\} + (1-\theta)\pi_{t-1} + \phi \hat{y}_t, \qquad (5)$$

where $0 \leq \theta \leq 1$.[8] We use the Hybrid model as our starting point, as it explicitly allows us to consider the extent to which using real time data affects the degree to which behaviour is forward-looking.

Expressing inflation in terms of prices and not wages on the one hand and demand pressure in terms of output gaps and related measures and not unemployment on the other is of course also making sweeping modifications to the original Phillips (1958) specification. However, our purpose here is not to innovate with specifications but to explore the impact of real time information on specifications that are already widely used. It would be readily possible to extend the analysis to other specifications in a subsequent paper, as it is by no means certain that the results would generalise.

3 Forms of real time information

There are three sources of real time information that we explore. The first relates directly to expectations. A common approach is to assume rational expectations and try to model expectations directly from the model. Rational expectations are normally expressed, however, in terms of the most up to date information. A construct based on the information available at the time could be made 'model consistent' but strictly rational expectations would imply that they were 'correct' not just that they conformed to a specific less-revised dataset. In any case, not only does the rational expectations assumption impose substantial problems for estimation (see Rudd and Whelan (2001), for example) but it perpetuates the problem of handling an unobservable (two actually since the output gap is also unobservable). We therefore consider a less ambitious assumption and employ a direct measure of expectations as a means of trying to get at what people thought at the time from the information available to them. We use published OECD forecasts. These forecasts were thus generally available at the time

[8] In Paloviita and Mayes (2003) we use a different version of (5) as an encompassing test of the Expectations Augmented and New Keynesian hypotheses in the form of Davidson and MacKinnon

pricing decisions were taken. While there is no particular reason to suppose that the OECD represented general beliefs, such forecasts were widely discussed and respected. More importantly from the point of view of our analysis, they are produced by a coherent methodology that is applied to each of the euro area countries and evolves only slowly across time.[9] There is nothing similar available with such a coverage. Even so with only annual data stretching over the period 1977-2003, this is a very limited sample to operate on. We have therefore chosen to pool the data and estimate the model in panel form, which gives us a maximum around 300 observations, depending on the exact specification.[10]

The OECD's forecasts are produced twice a year and published in June and December. The June forecasts are normally for the current and the next calendar year, while a second future year has been added in December, in recent years. They cover, inter alia, inflation in both the GDP and consumer price deflators. OECD's database is quarterly, so it would be possible to compile semi-annual series for all the variables and estimate the models on that frequency. One can also interpolate the series of forecasts and hence estimate the models at quarterly frequency.[11] However, we have chosen to stick with the annual information. The timing of the forecasts raises the first question about what real time constitutes. Pricing decisions that affect both deflators will be taking place during much of every working day and probably outside them as well. The annual outcome is the result of a mass of decisions spread, unevenly over the year. There are some important elements of bunching in the early part of the year, both with administered prices and wage-setting in many euro area countries over the period. This

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(1993) to explore whether the currently expected future inflation of the previously expected current inflation dominates the inflation process: $\pi_t = \theta \mathrm{E}_t\{\pi_{t+1}\} + (1-\theta)\mathrm{E}_{t-1}\{\pi_t\} + \phi\hat{y}_t$ (6)

[9] Of course, as a referee pointed out, coherence per se is not a virtue. If the underlying methodology were flawed it could introduce biases that would not be present under incoherence.

[10] Not all series are of equal length and the availability for particular countries varies slightly. It is, however, the forecast information that starts in 1977 for ten countries in the euro area. For Luxembourg, the forecasts are available since 1982 and for Portugal since 1980. We can and do go back earlier to 1960 with the historical series published by the OECD since 1977, particular in the case of real GDP, when estimating output gaps.
A referee pointed out that we face somewhat of an irony in using panel data. If we wanted to obtain estimates for the euro area as a whole then we might do better to focus on the larger countries as the smaller ones might merely increase the noise in the estimates. On the other hand if we are interested in the richness of variety across the countries then using panel estimation will cover some of it up.

[11] Normally interpolation is done with some reluctance because of the effect it has on the dynamics of the relationship. In this case it might actually be desirable because the OECD forecasts are only a proxy

might argue that the December forecasts were more typical of the information available. On the other hand the June forecast coincides with the publication of the first estimates of the outcome for the previous year, so perhaps this has more merit. We explore both but we focus on the December forecasts because they enable a look slightly further ahead than their June counterpart.[12]

To prejudge the outcome, the results are importantly affected by which forecasts are used to represent expectations – in a sense that is only to be expected given how crucial the dating of the expectation is in distinguishing the two hypotheses. The big advantage of using OECD forecasts is that in the self-same publication the OECD produces compatible data series for the history of the variables in the model and estimates of their current value.[13] Since we are dealing with estimates made in December for the current year, they still contain an element of forecasting. This emphasises a general problem in estimation in that reliable official estimates may only be available with a considerable lag. The first published vintage of the data for a particular year are not really 'real time' as they appear after the decisions have taken.[14] In the section on the output gap we attempt to use the OECD's own 'real time' estimates of the output gap published in *Economic Outlook* as well, so that the entire model is expressed only in terms of the information actually used at the time price setting decisions are made. Otherwise it is necessary to estimate the gap using relatively robust

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and some smoothing of their impact might be appropriate. We only take them as representative of a more general view, not that their publication constitutes 'news' on which behaviour would change.

[12] These differences in horizon and information base pose problems for a semi-annual approach. Not only will the timeliness of the published information available alternate between the June and December OECD estimates but the length of the forecast horizon will also vary by six months.

[13] Most of the data can be taken from the various issues of OECD *Economic Outlook*. However, prior to 1985 (1983 for France, Germany and Italy) *Economic Outlook* did not contain estimates of inflation two periods earlier. These real time estimates are needed for the instrument set. We therefore used the nearest estimate in time published in the OECD *National Accounts.* As described in the text, we had to take a somewhat ad hoc view of which year's estimates to use. The decision was based on the degree of correlation between the *National Accounts* and the *Economic Outlook* estimates in the years from 1985 onwards where we had both sets of estimates. This was done on a country by country basis, as the lag in information provided to the OECD by the national statistical authorities varies. For five countries the current year *National Accounts* were used and the next year's for the remainder. While this muddies the definition of real time somewhat, the effect is likely to be small. The major consequence is the irritation of having to collect each issue of a second data source in order to compile the database.

[14] This would not be such a problem with a backward-looking specification or higher frequency model, if data are published quickly. As it is, the current year 'estimate' will be based on initial published data for the first part of the year, estimates of related and indicator variables for the middle part of the year and forecasts combining backward and forward-looking information for the last few months of the year.

methods to represent what could been done over the period with the real time data and the techniques then available.

The second element of real time information thus relates to the data set used in constructing the output gap. If we use up to date information we actually know with the benefit of hindsight what happened to output in subsequent periods and hence can avoid the well known end point problem. However, at the time people face the end point problem. They have to make judgements about how appropriate trend values should be estimated and as Orphanides (2001) has shown this can help explain some large policy errors. HP filters are particular subject to this difficulty and it would be very helpful if we could use a different form of estimation, say, the production function approach that the OECD uses. It is arguable (Neiss and Nelson, 2002; Robinson *et al.*, 2003; Orphanides and van Norden, 2002) that the problems with estimating the output gap will dominate the problems, that people at the time faced from having to use real time data. However, using more sophisticated methods would not be a replication of what people might reasonably have done at the time.[15] It is particularly unfortunate therefore that these potential less contaminated estimates of the output gap by the OECD only stretch as far back as 1994. We are therefore compelled to use the HP filter or similar rather deficient methods if we want to consider the whole of our data set. Nevertheless at least we can use the full extent of the OECD output forecasts available in calculating the filter. However, when pooling we can use these real time OECD output gap estimates rather than our HP proxy of them, as this provides enough degrees of freedom for reasonable estimates. In any case, in estimating the output gaps themselves, as they would have been seen at the time, we need to use real time data.[16]

Lastly in estimation, we apply real time data in the GMM estimation process. Here the question of what data set should be used is more contentious. GMM is a statistical technique. Appropriate instruments need to be predetermined and correlated with the variables they seek to explain but uncorrelated with the error term. Using GMM does not per se involve the question of what information was available at the time. It might however, seem more logical to use a common data set so that the

[15] Using 'one-sided' filters may reduce the problem.

instruments are also what was available at the time. By using more up to date information in one part of the estimation process than in another we may introduce spurious correlations. The issue of simultaneity would be represented by using the same real time data set even if it might be statistically easier to handle it with different information. In this sort of context one of the functions of GMM is to help clear up an 'errors in variables' problem. If we assume that the final estimates are more accurate then inevitably the real time estimates must include an error. We conduct some limited tests for bias to see if we can get a prima facie indication. However, this may turn out to be a second order problem. Our concern at this stage is simply to explore whether the problem is of any real importance.

We thus have quite a complex database that contains a series for each variable in the model every year. Since we have used 26 issues of the OECD *Economic Outlook* annually from 1977 to 2002 we have 26 sets of series on each variable.[17] Thus the real time data for a variable x in period t consist of series running from the first year recorded, 1960 in most cases, through to $t + 2$, i.e ${}_{t}x_{1960+\tau}$, $\tau = 0, \ldots, t + 2$; $t = 1977, \ldots, 2002$. The observations from 1960 to t - 1 will be published 'data', t will be an 'estimate'[18] and $t + 1$ and $t + 2$, are forecasts, all published by the OECD in December of year t. These then have to be placed into the appropriate series for estimation. Real time forecasts made in year t for year $t + 1$ are thus denoted ${}_{t}x_{t+1}$, real time lagged values are ${}_{t}x_{t-l}$, where l is the lag, and forecasts made last year for this year are ${}_{t-1}x_{t}$. Thus there is always a contrast between real time and the most recently published estimates. However, for the last data point, 2002, the most recent data have not as yet been revised. Since many of the main revisions occur early in the first year or two, we could end the real time data earlier by eliminating the most recent observations if we wished to increase the potential difference between the last real time observation and the most recently published revised estimate. How many years we should omit in this way is fairly arbitrary unless we could reach a point where the data are not further revised.

[16] There is clearly a trade off here between considering robust methods of estimation using real time data that might have been more in line with contemporary estimates and using more reliable estimates. The difference between the two may help to explain policy errors.

[17] We have a 27th set of series from the December 2003 *Economic Outlook*, which is the source for our most recent revised data. The last complete year is thus 2002 as 2003 was not yet over in December. Hence the 2003 real time estimates cannot be used as they have no 'actual' value against which they can be compared.

Since that involves knowledge of what the statisticians at the OECD might do in future revisions, which they themselves do not know, there can be no 'right' answer. The more periods we omit the poorer our explanation of the Phillips curve is likely to be. There is thus a trade off. We can gain some insight over the appropriate choice from the pattern of previous data revision by the OECD.

As is illustrated by Figure 1 for the four largest economies in the euro area, there are typically two sorts of revisions to the OECD data. In the first few periods there may be fairly substantial revisions and then at less frequent intervals there are comprehensive revisions to the series over quite a long time period, usually coinciding with rebasing, particularly for constant prices. This second type of revision tends to shift the series as a whole rather than simply individual observations. This difference is important in context of the Phillips curve, as variables are expressed either in rates of change or compared to some form of 'trend'. Shifting a series may have little effect on rates of change but it can alter the complexion of deviations from trend, particularly where there are nonlinearities or asymmetries. It is noticeable that the revisions have typically been greatest round the turning points. Since turning points are also associated with forecast errors, this has the potential for even larger real time discrepancies. It is also observable that there can be noticeable changes even 10 years or more after the event. The second issue can matter much more for the output gap, Figure 2, as it is a derived measure and not just a published series. Here we can see that while the shape of the output gap does not change a lot, where it is pitched can. The revision for Spain between 1999 and 2000 is particularly striking but its greatest effect is not on the immediate period but on the estimates of the fairly recent past.

[18] They are all of course estimates in the sense that we never know the true values.

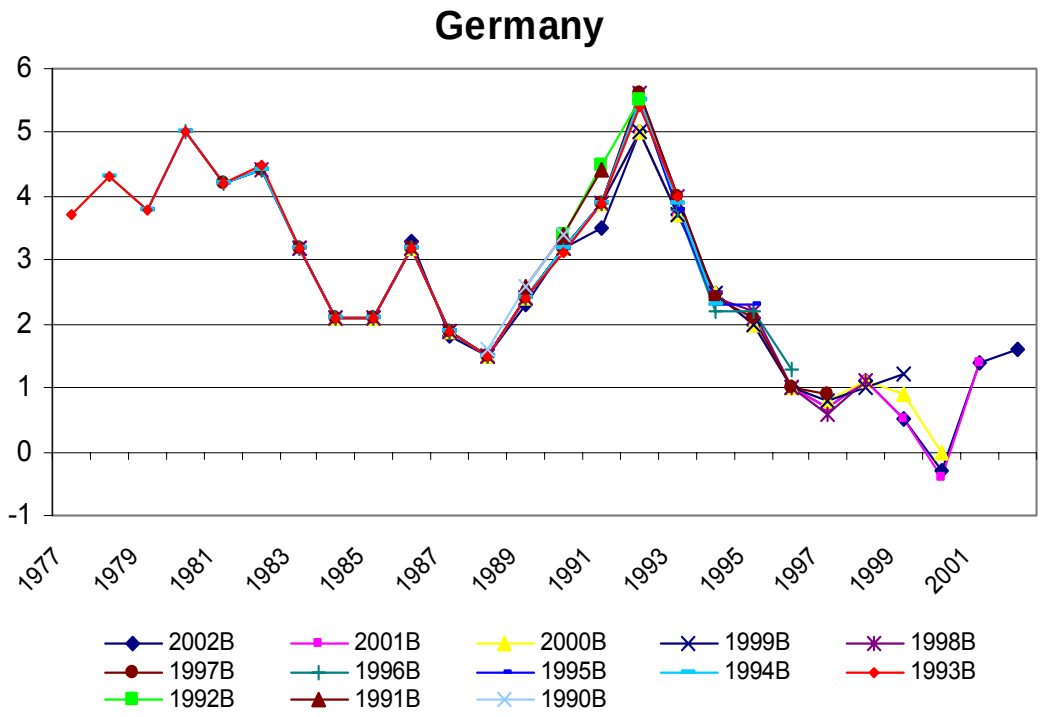
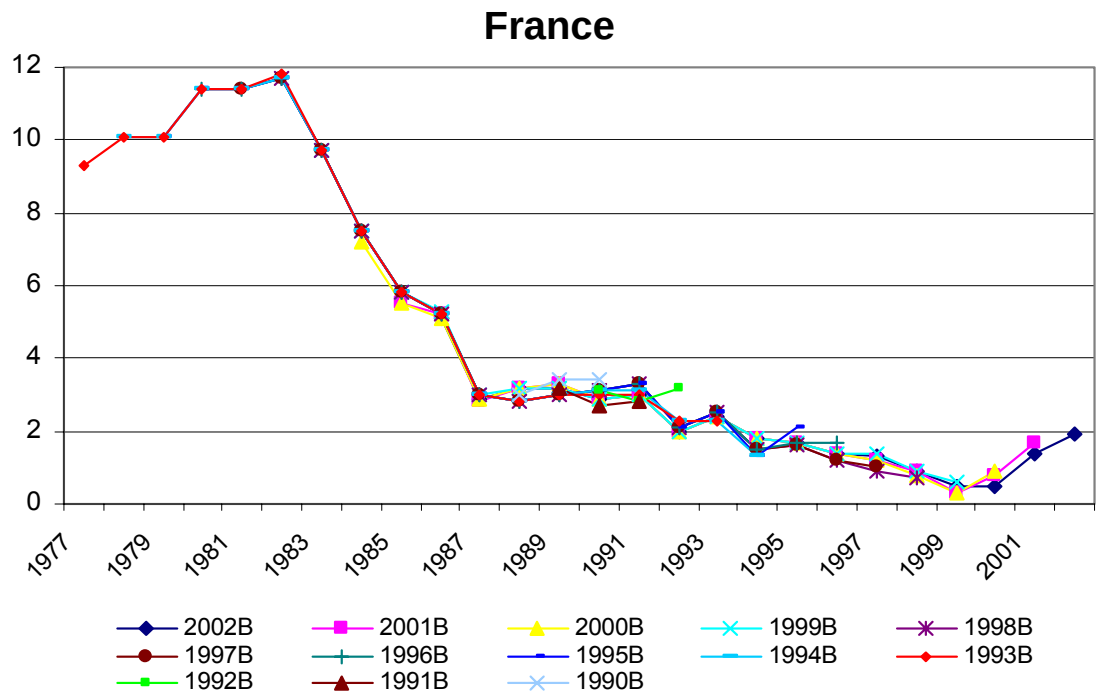


Figure 1: Real Time GDP Deflator Estimates, 1999-2002



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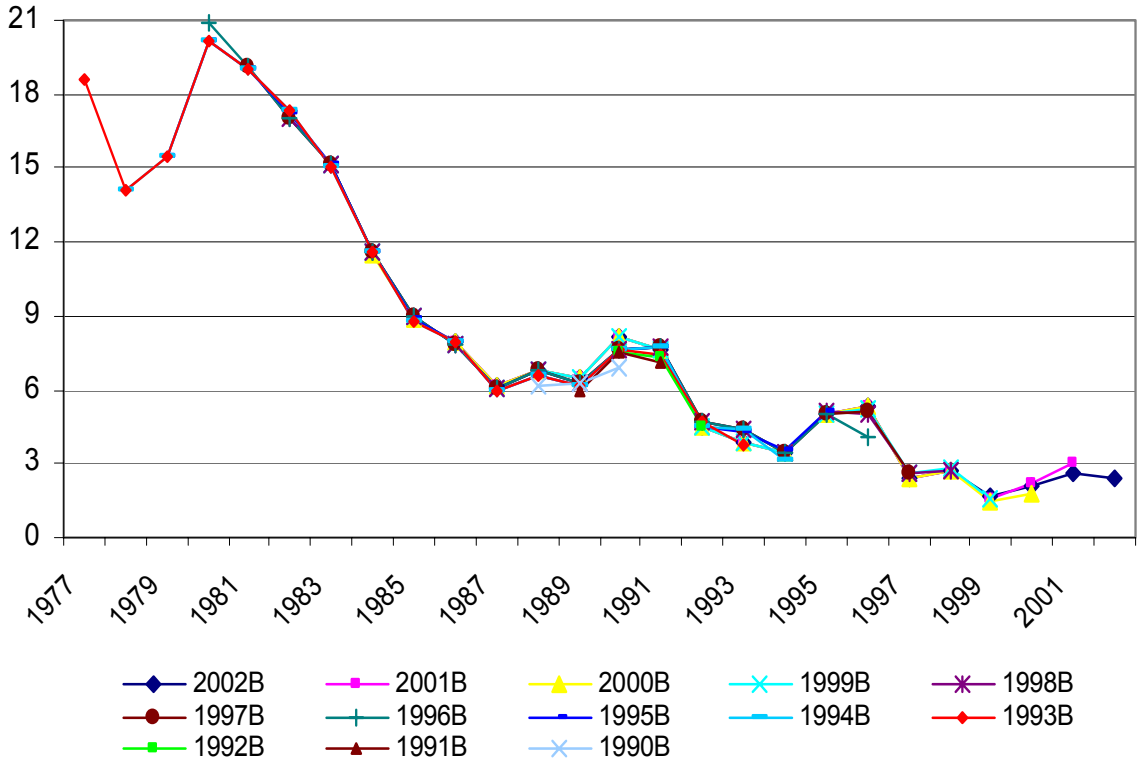
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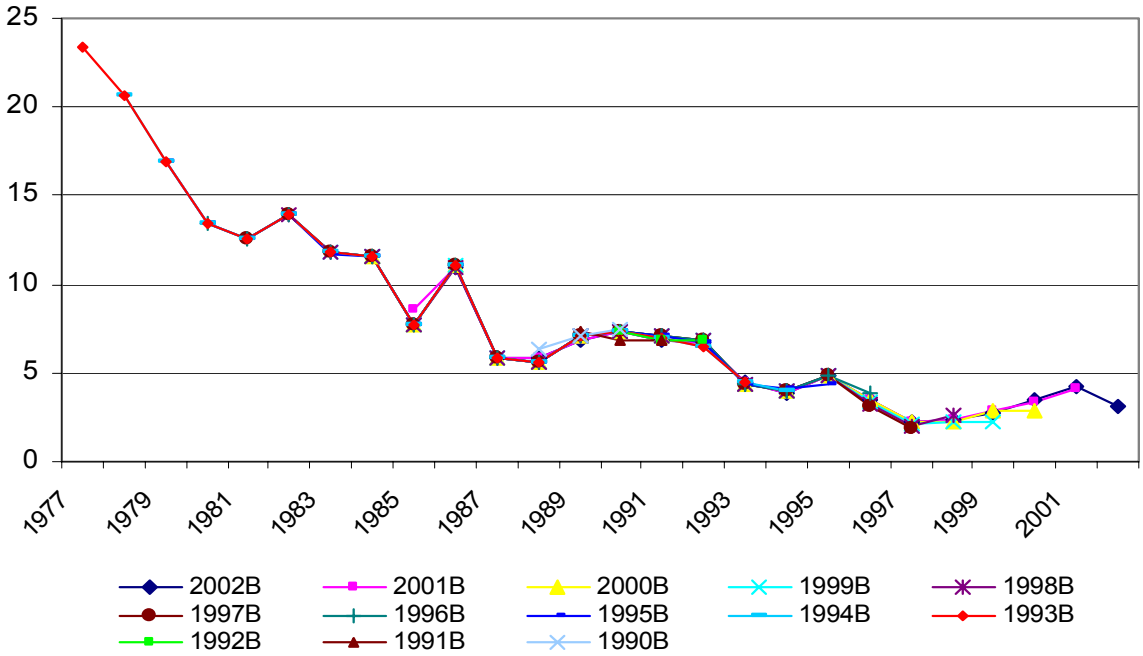
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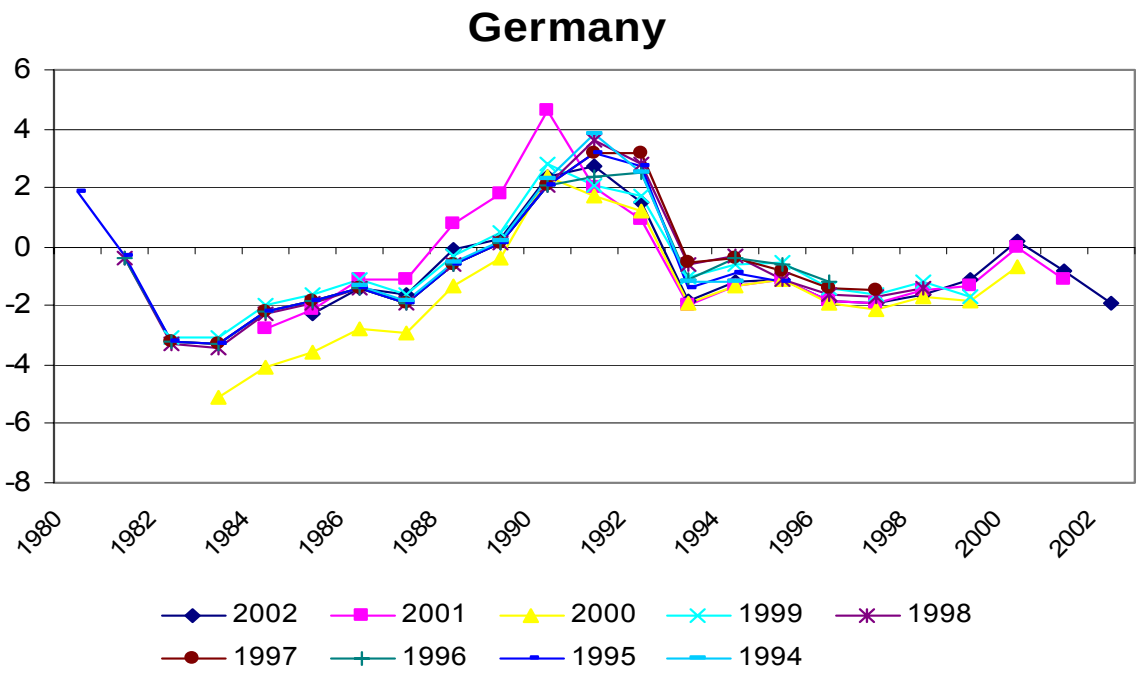
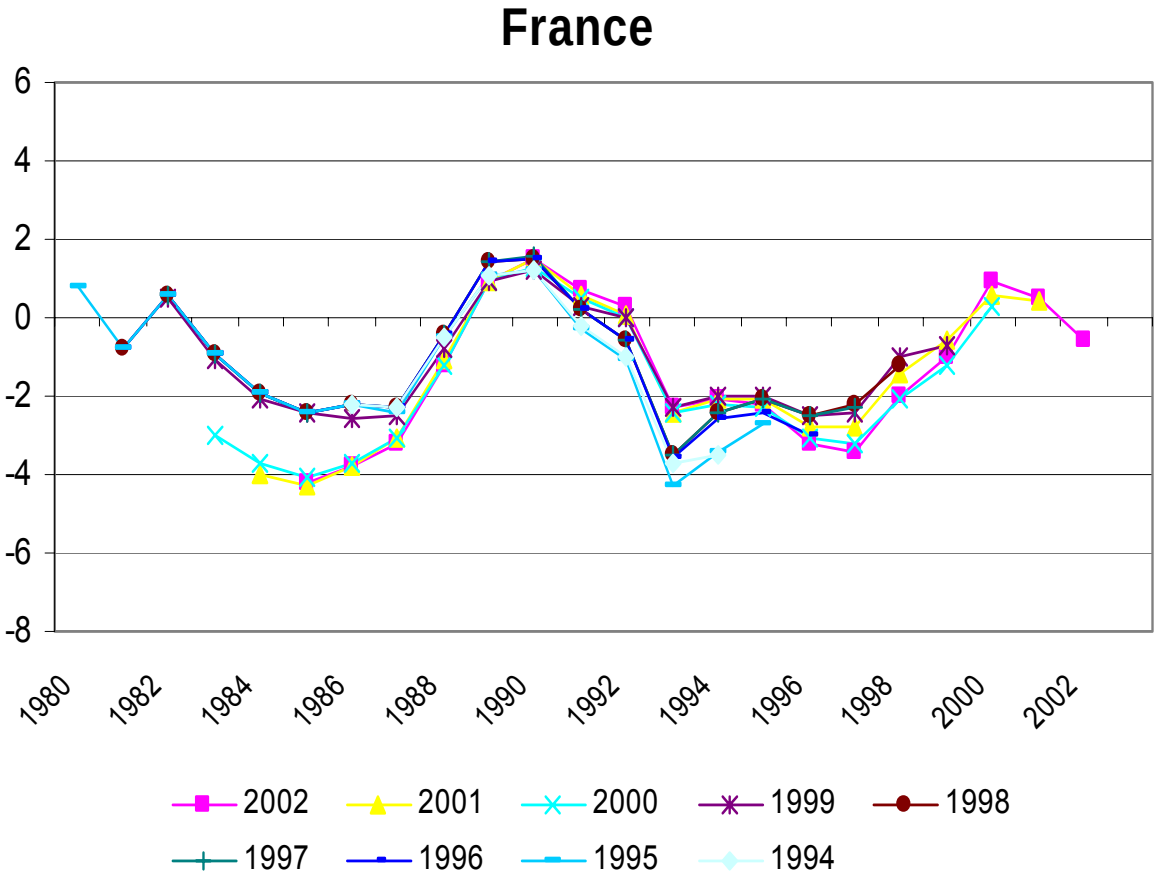
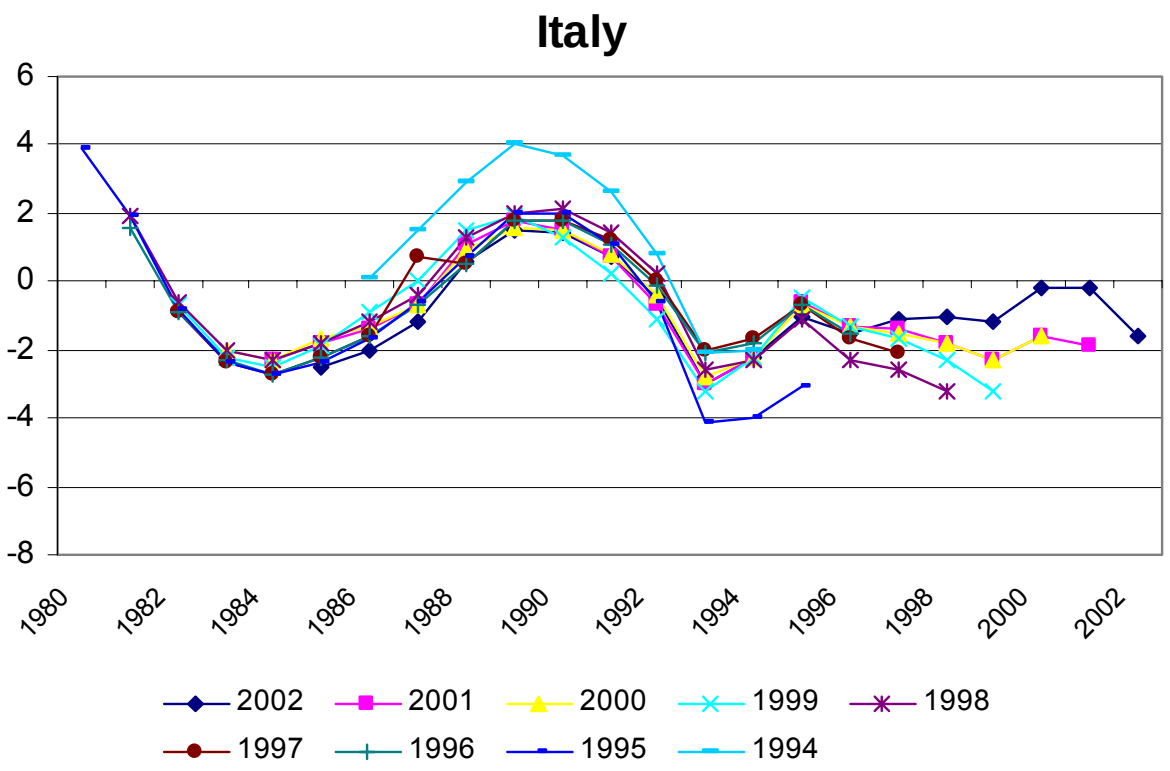


Figure 2: Real Time OECD Output Gap Estimates 1994-2002

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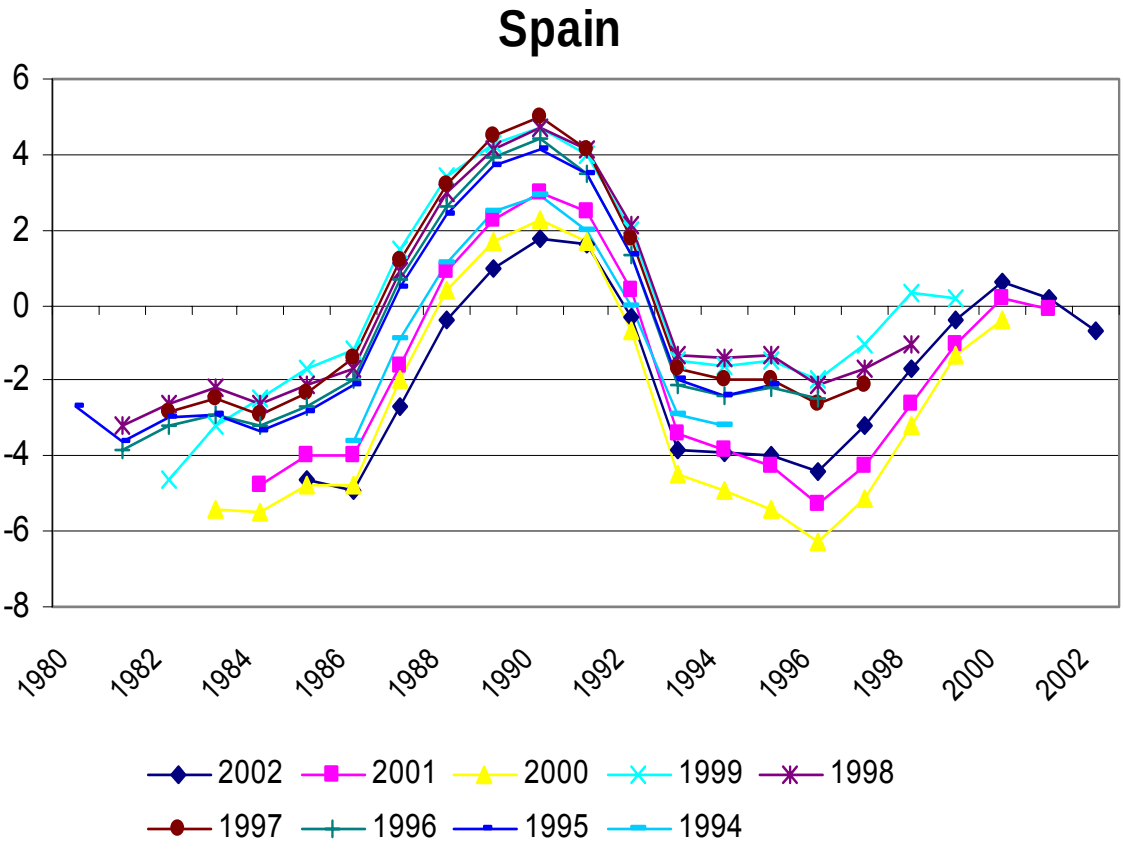
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It is fairly obvious that our inflation series are highly related, Table 1. The real time series typically show correlation coefficients of 0.95 or better with both the revised estimates and with the forecasts. In the case of the output gap however, we are looking at markedly different series, with correlation coefficients between 0.6 and 0.9. Interestingly, in the long sample the revised HP filtered output gap is more correlated with the revised OECD estimate than with the real time HP filtered output gap. The same is true in the shorter sample, which shows that when using the HP filtering, the correlation between the real time and revised output gap is smaller than in the case of the OECD output gap estimates, which are based on the production function method.

We have also checked to see whether the discrepancies appear to be biased. In general, consistent departures from the revised data are indicated by simple Wald tests comparing the real time and revised estimate. The exceptions are the OECD's own output gap estimates, which use a production function approach and the real time GDP deflator. The nature of the discrepancy varies from case to case. The real time HP filter estimate of the output gap is on average about half of one percentage point below the estimates from the most recent data. We had anticipated that the end point problem would bias its absolute value towards zero, not this asymmetric bias. Real time consumer price inflation tends to underestimate the revised series. The OECD's estimates have such a low correlation with the HP estimate of the output gap that it is not surprising if no bias is detected even though the average value is nearly 0.4 of a percentage point lower.

There is one correlated item in the revisions. Since real GDP is deflated nominal GDP and the GDP deflator is one of the inflation measures we use in the study, revisions to real GDP could come from one or both of two sources. Nominal GDP and/or the GDP deflator may have been revised. Thus there will tend to be some inverse correlation between revisions of real GDP and the GDP deflator. The change to the output gap, which is derived from the GDP series will be at one remove. Since the output gap for a single year is not dependent on GDP in just one year, it is not possible to go on to argue that revisions in the output gap and in the GDP deflator are therefore also likely to be correlated but it remains a possibility. In so far as such correlations do exist they can affect the extent of the change in the estimates from using real time data.

Table 1: Correlations and Wald test for unbiasedness

Correlations 1977-2002

GDP deflator	Revised	Forecast	Real time estimate
Revised	1	0.953	0.976
Forecast	0.953	1	0.963
Real time estimate	0.976	0.963	1
CP	Revised	Forecast	Real time estimate
Revised	1	0.955	0.991
Forecast	0.955	1	0.951
Real time estimate	0.991	0.951	1

Output gap	Real time HP filtered	Revised HP filtered	Revised OECD estimate
Real time HP filtered	1	0.604	0.577
Revised HP filtered	0.604	1	0.859
Revised OECD estimate	0.577	0.859	1

Output gap correlations 1994-2002

Output gap	Real time HP filtered	Revised HP filtered	Real time OECD estimate	Revised OECD estimate
Real time HP filtered	1	0.679	0.873	0.627
Revised HP filtered	0.679	1	0.746	0.881
Real time OECD estimate	0.873	0.746	1	0.769
Revised OECD estimate	0.627	0.881	0.769	1

Unbiasedness

$\boldsymbol{\pi}_t = \mathbf{a} + \mathbf{b}\boldsymbol{\pi}_t^*$ or $\mathbf{y}_t = \mathbf{a} + \mathbf{b}\mathbf{y}_t^*$ Joint hypothesis (a,b) = (0,1)

	F-statistic	*Probability*	*Chi-Square*	*Probability*
Real time GDP deflator	0.102	0.903	0.204	0.903
Real time CP	5.616	0.004	11.231	0.004
Real time HP filtered output gap	8.621	0.0002	17.243	0.0002
Real time OECD output gap	2.068	0.132	4.137	0.126
GDP deflator forecast	5.875	0.003	11.751	0.003
CP forecast	5.269	0.006	10.537	0.005

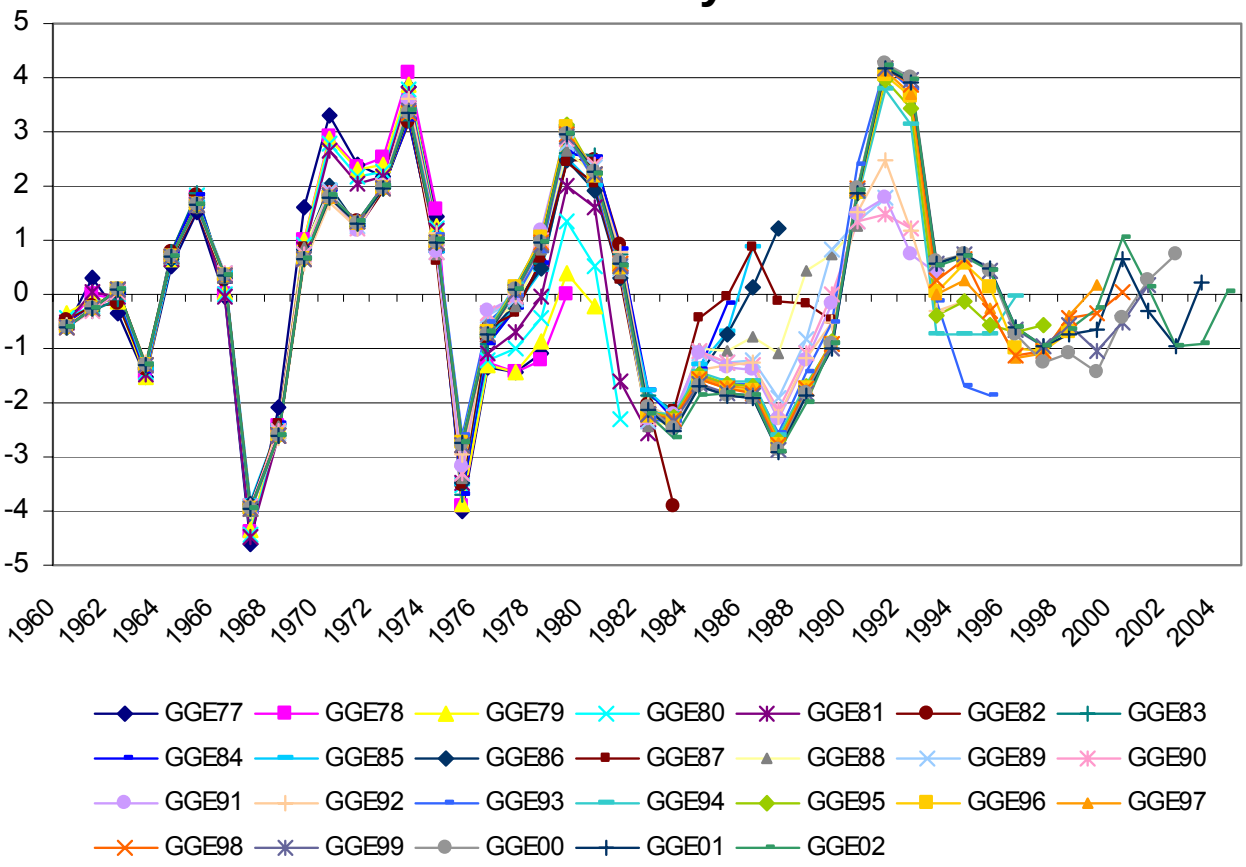
We face the normal problems in constructing the output gap and use an HP filter, not because it is obviously best but because it is the most widely used approach that does not involve further data series.[19] We follow the common procedure of using forecast values of real GDP to construct the filter in order to reduce the impact of the end-point problem. This only has to be done once with the most up to date data set. However, if we want real time output gaps we have to construct them from each data set in turn. Thus in period *t*, computing the output gap entails using the December year *t* OECD *Economic Outlook* to provide the most up to date estimates of real GDP in previous years, the estimate of year *t* and the forecasts of year $t + 1$, and $t + 2$ where it is available. All these estimates of the year *t* output gap, one from each December's *Economic Outlook*, have to be transcribed into the single output gap series for estimation. When using the OECD's own published estimates of the output gap, which use a production function and not an HP filter, they are treated just the same way as the most recent and real time series for the inflation variable.[20]

The evolution of each individual computation of the real time output gaps in Germany, France, Italy and Spain is shown in Figure 3. The first real time gap is thus computed for 1977, the beginning of our forecast sample, using the December 1977 vintage data including its forecasts. This line has its end point in 1978. There is then a new line superimposed for each succeeding year, all of them stretching back to 1960, which is our origin year for the data. This sequence of gaps, without the history are shown in Figure 4 by comparison with the HP filtered gaps estimated using the most recent, December 2003, data. The deflators tend to show quite negligible differences by comparison, Figure 5. This is, however, just four countries out of twelve, albeit the largest.

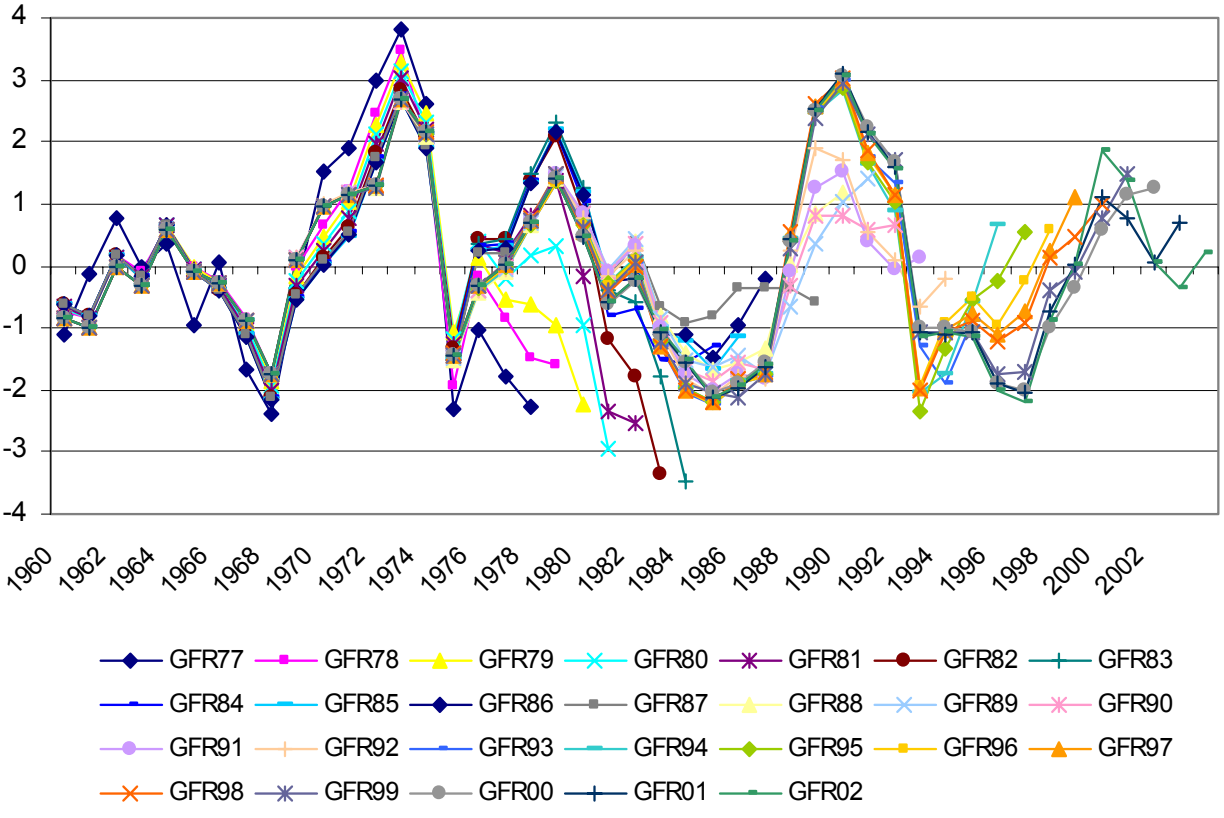
[19] As Rünstler (2002) has shown for the euro area, Orphanides and van Norden (2002) for the US and Cayen and Van Norden (2002) for Canada, Nelson and Nikolov (2001) for the UK and Gruen *et al* (2002) for Australia, measures of the output gap can vary widely according to the method used.

[20] The OECD has only published its own estimates of the output gap since 1994. The correlations of these with other measures are therefore presented separately in Table 1. It is interesting to note that the OECD's initial production function based estimates are better correlated with the real-time HP filtered estimates, despite the crude method of estimation, than they are with the revised estimates.

Germany



France



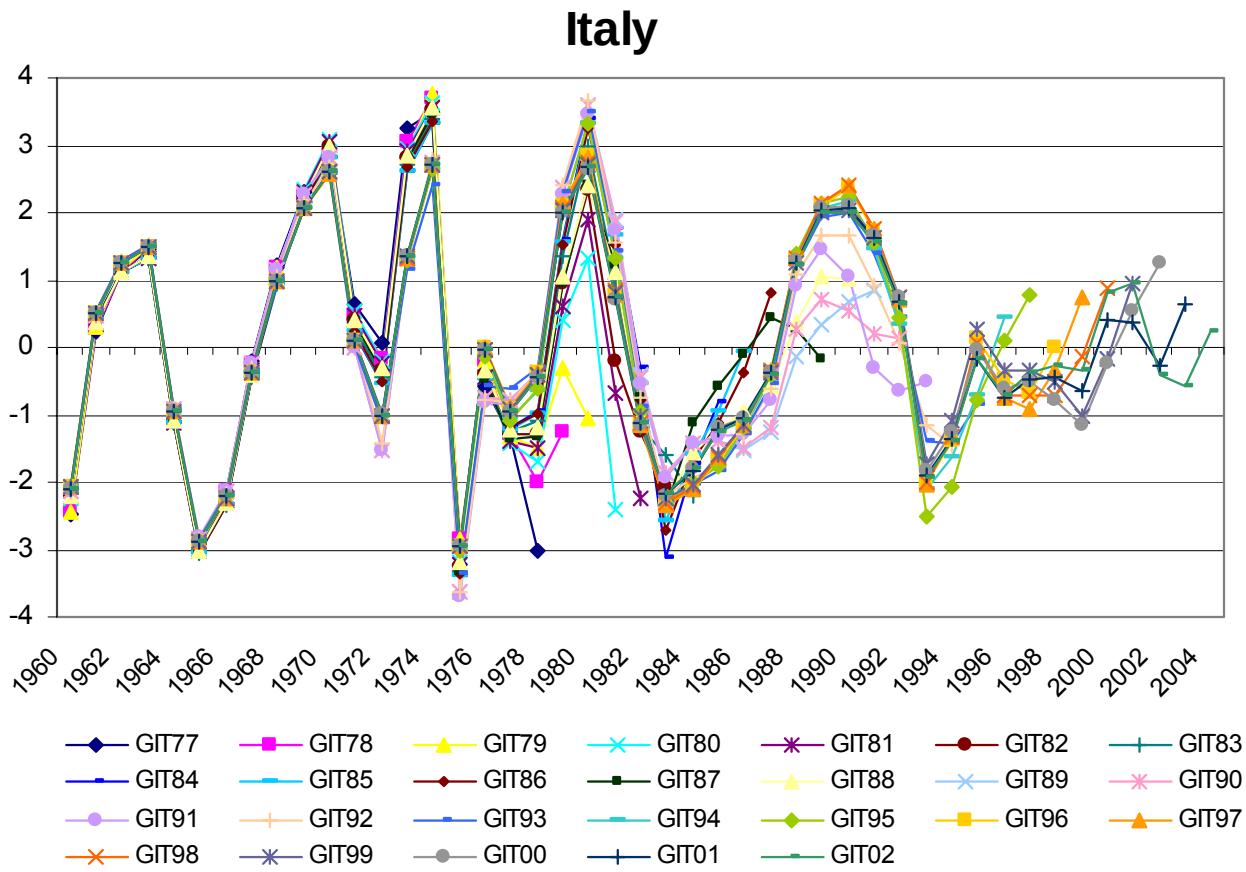
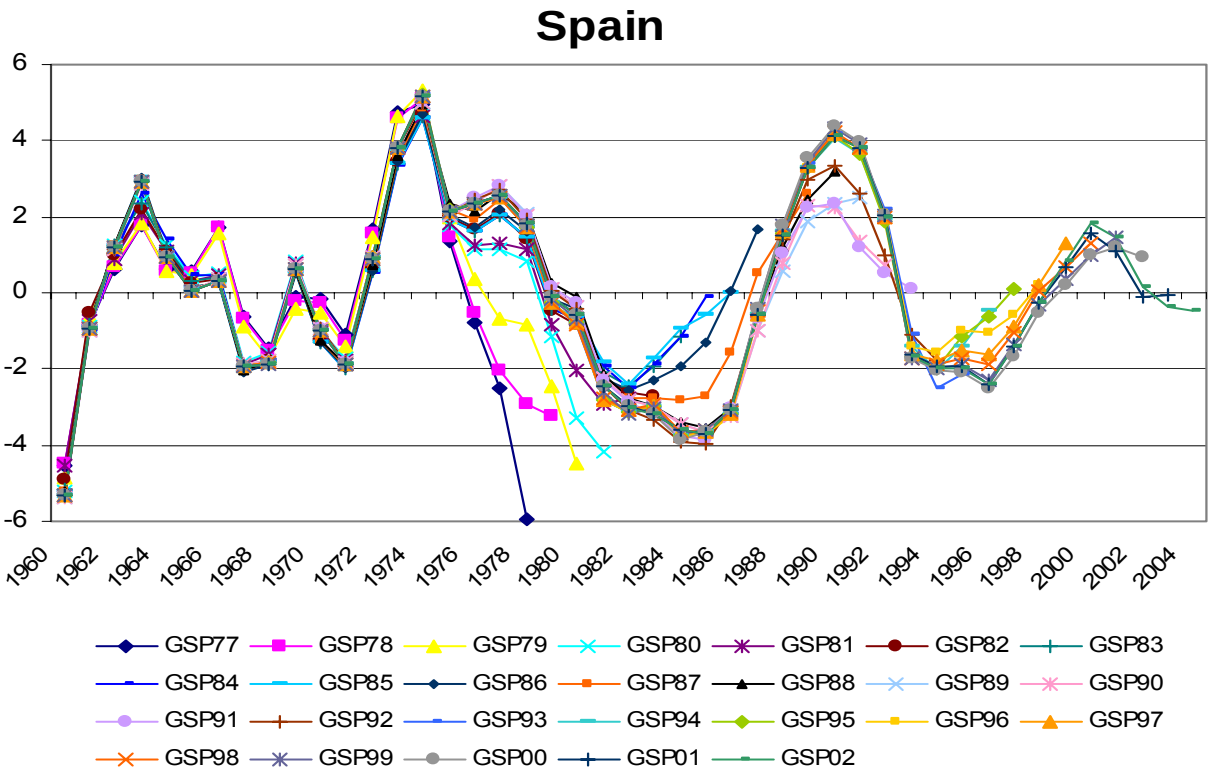


Figure 3: Real Time HP Filtered Output Gaps



3. The Empirical Framework

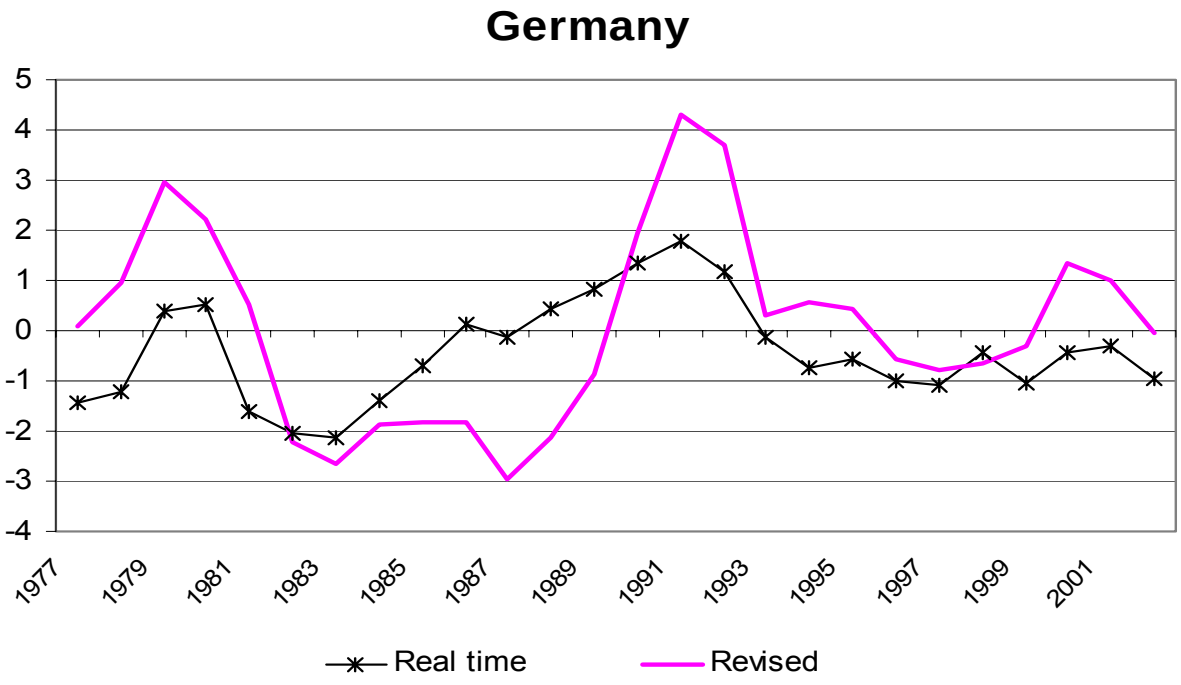
In order to make the Phillips curve specifications as comparable as possible for the euro area data, we have applied the same method of operationalising expectations and the same measure of excess demand to all cases. In the New Keynesian specification (2), current inflation is dependent on the *currently* expected future inflation. In this case the parameter β is the discount factor, which is less than but very close to unity. We impose 0.99 as reflecting the average real interest rate over the period but the estimates are not sensitive to values in the plausible range.[21] Indeed we should note that unconstrained estimates suggest very similar results for the importance of the different bases for the formation of expectations. In the Expectations-Augmented specification current inflation is related to the previously expected current inflation, as shown in (1).[22] The Hybrid model (5) combines the same currently expected future inflation as in the New Keynesian case with actual inflation in the previous period. We

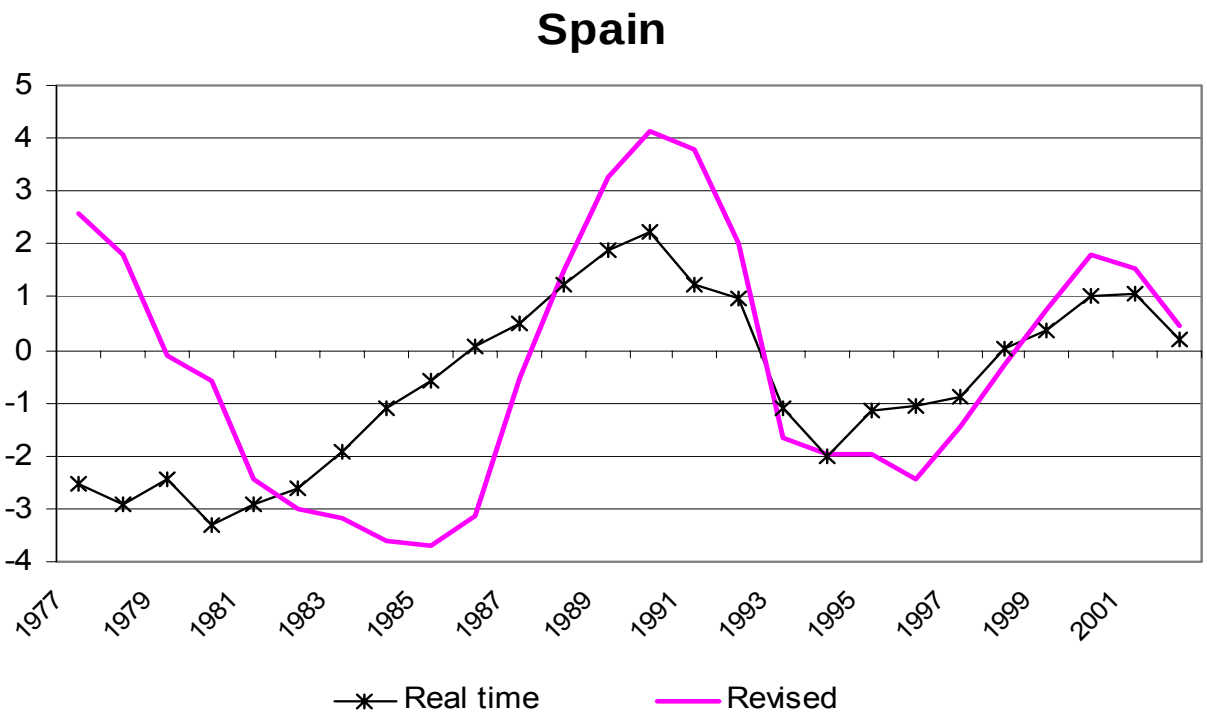
[21] With one exception for Germany, the results are very robust to changing the discount factor within the plausible range of recent experience. Since we have an estimate of inflation expectations we could use this to compute the real interest rate for each observation but this would add complications for the complete future stream of costs.

[22] We have also tested for non-neutrality in inflation process by estimating: $\pi_t = \beta \mathrm{E}_{t-1}\{\pi_t\} + \lambda \hat{y}_t$ (1')
Under neutrality the parameter β = 1. In only two cases is the restriction rejected.

constrain the coefficients to sum to unity, a restriction that is not rejected by the data. We used two inflation measures in estimation: the annual changes of the GDP deflator and the private consumption deflator, because both measures are widely used in the existing literature. Although the two series are strongly correlated, the show noticeable differences in estimation.

Figure 4: Real Time and Revised HP filtered output Gaps





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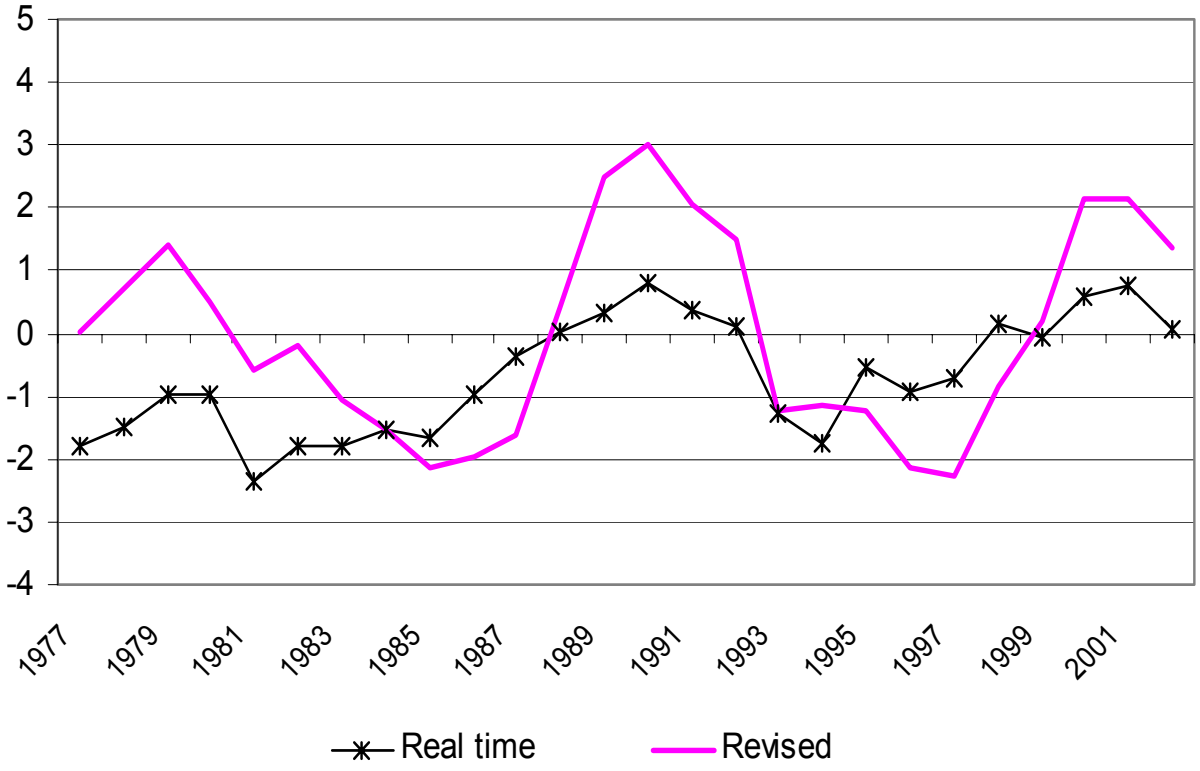

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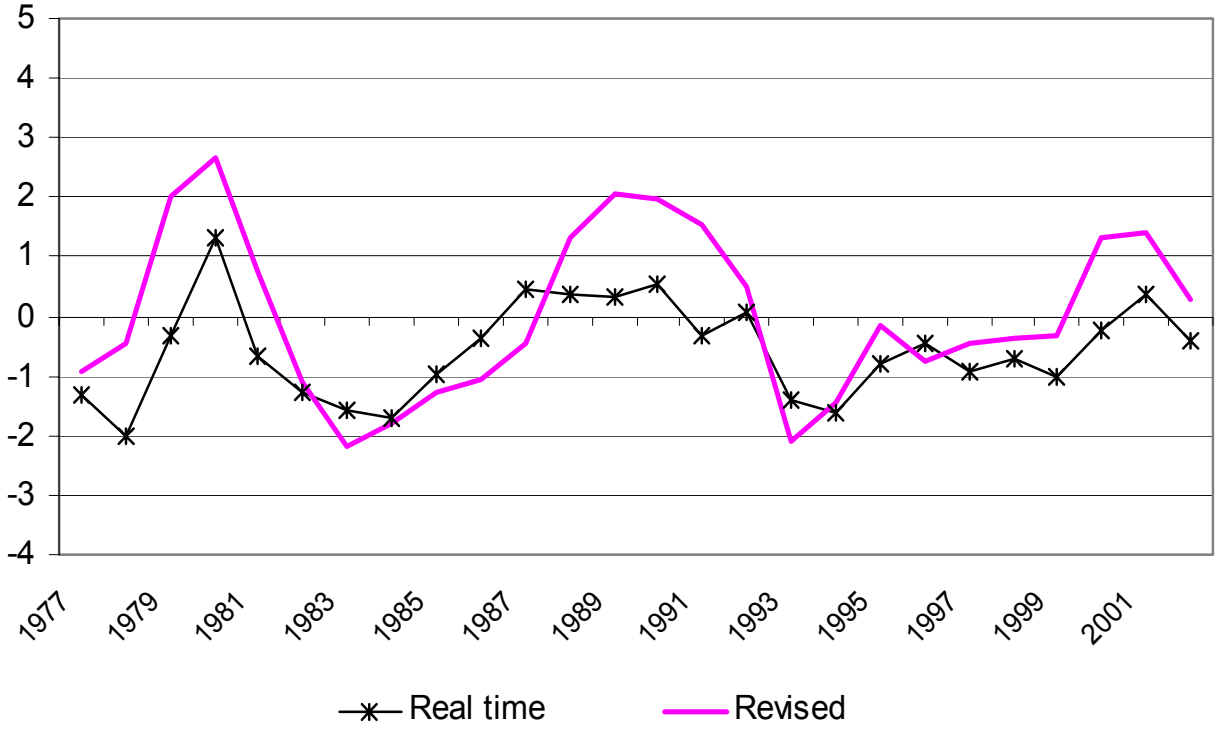
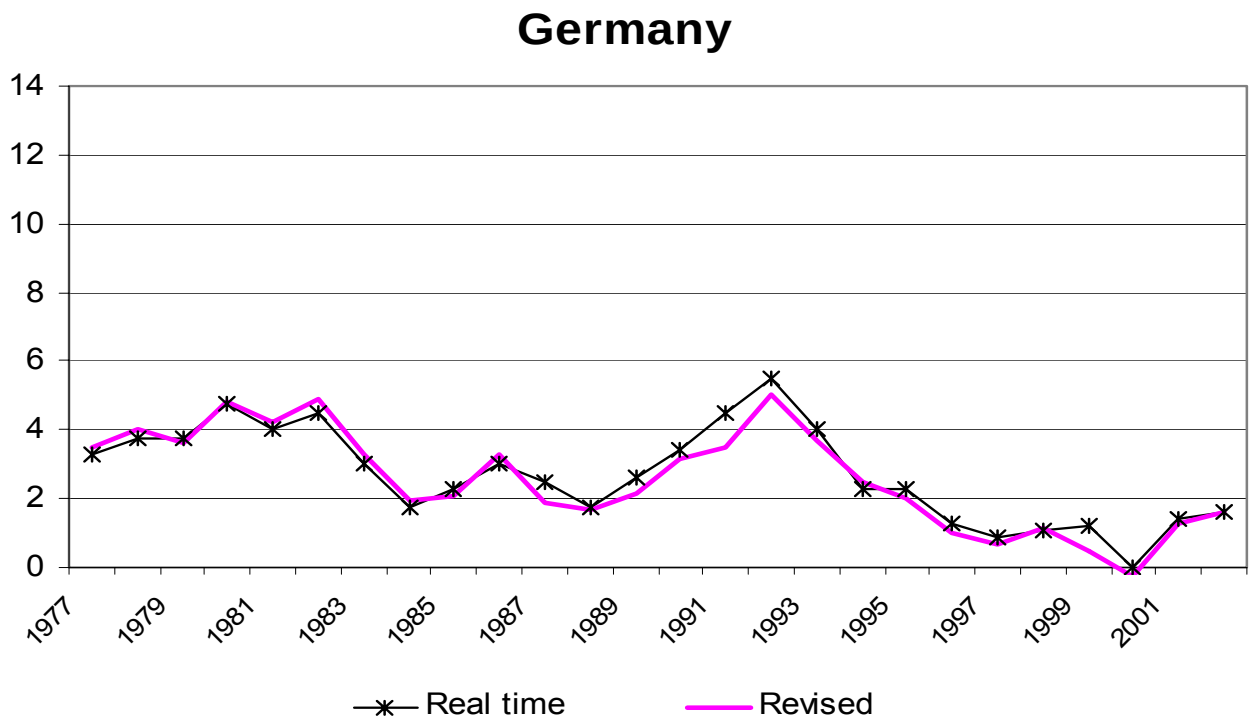
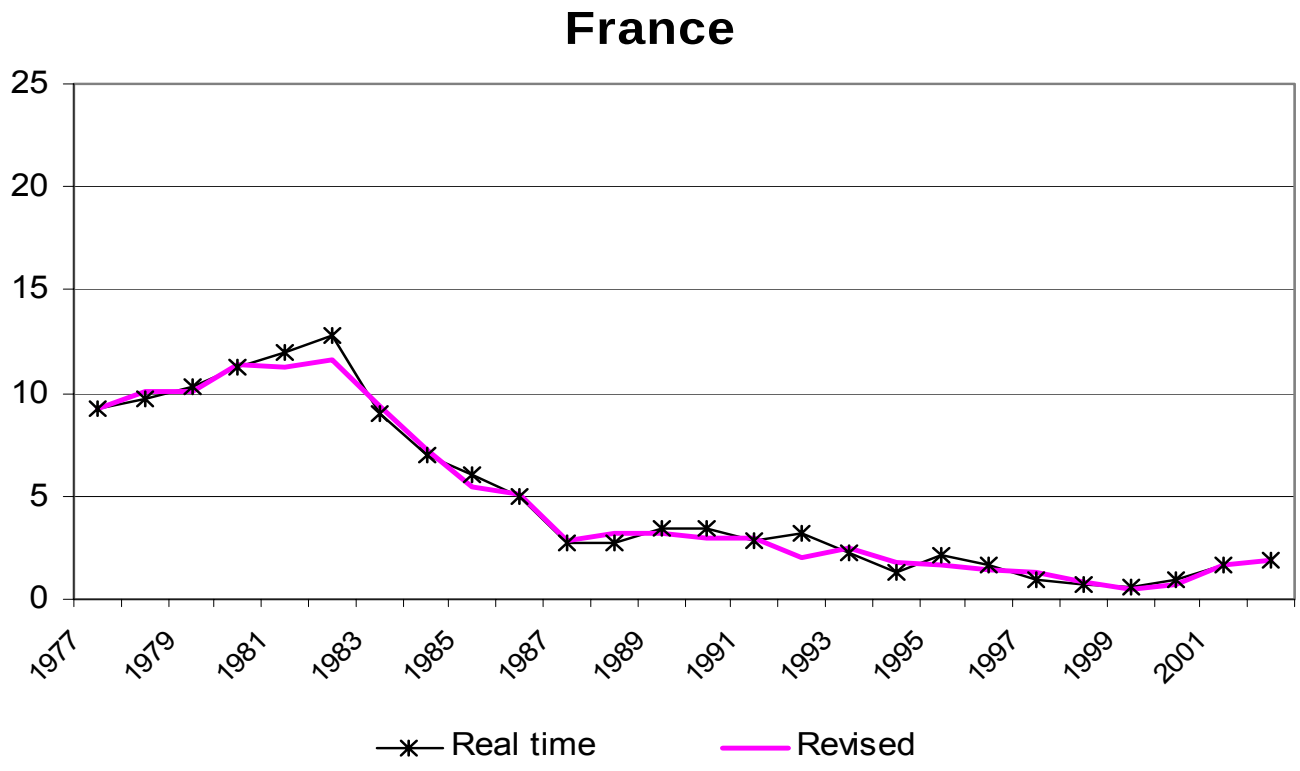


Figure 5: Real time and Revised GDP Deflator





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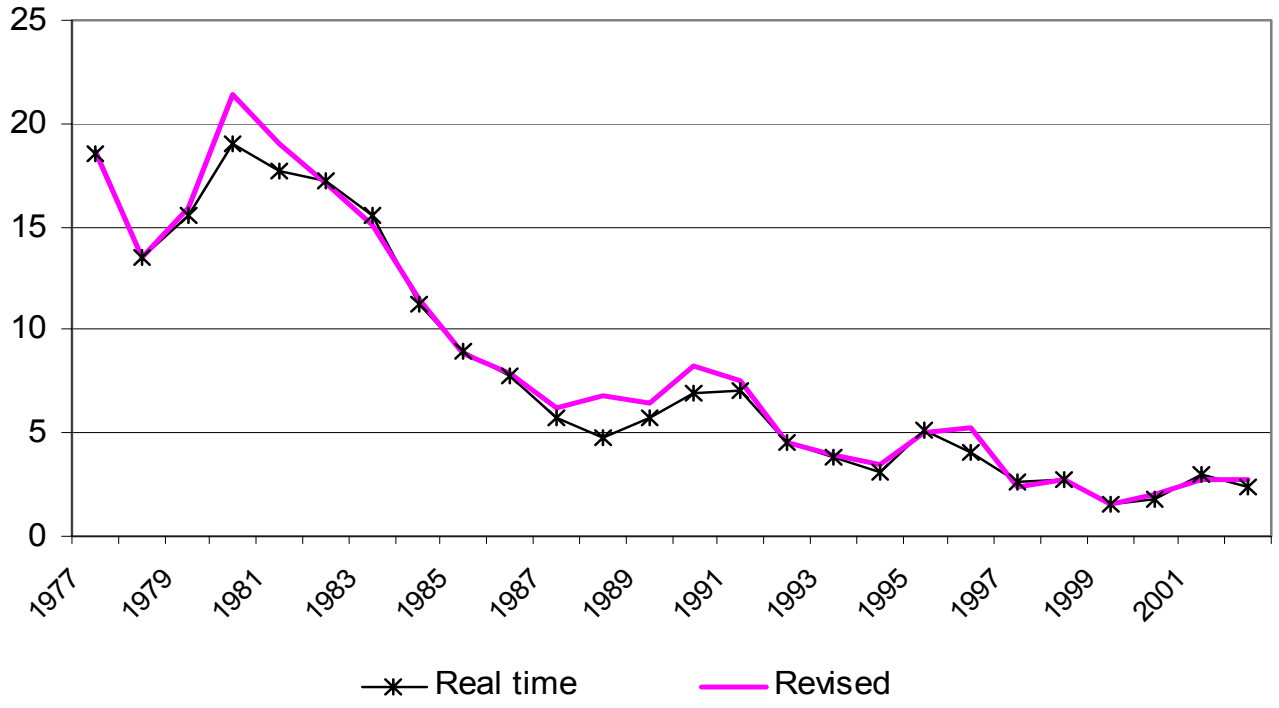
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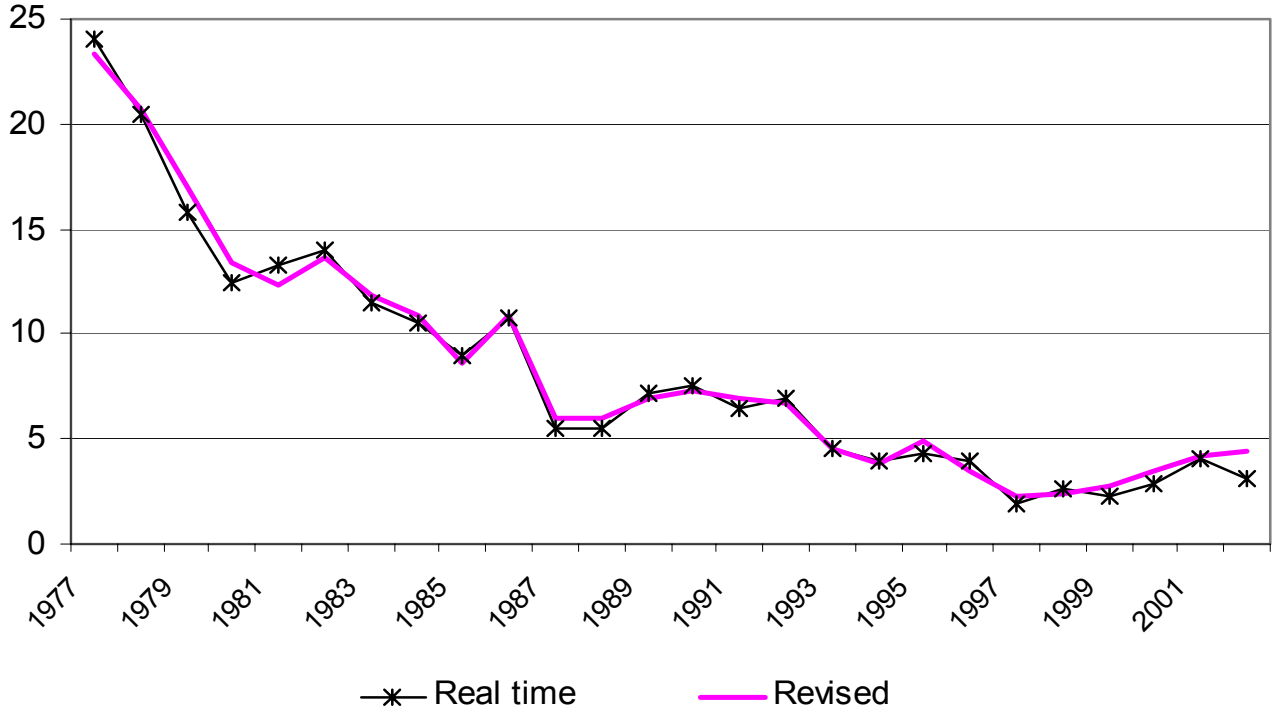
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The corresponding OECD forecasts are used to measure inflation expectations. By using direct measures of inflation expectations, we can avoid the problem faced by many previous studies of inflation dynamics, of having to test dual hypotheses, about the specification of the Phillips curve and the formation of expectations, at the same time.[23] Thus, in our study we can allow for the possibility that the expectations themselves may adjust slowly or move for spurious reasons. A simple form of explanation would be to use one of the specifications of least squares or other learning processes (Evans and Honkapohja, 2002). The OECD forecasts are likely to be more reliable proxies for inflation expectations than some survey estimates that have been used, as they are based on systematic monitoring of economic developments and econometric models. In using these proxies for inflation expectations, we can also test whether the lagged inflation rate is needed to improve the empirical fit of the Phillips relation. This test is equivalent to the Hybrid model used in Galí and Gertler (1999) in the case of the New Keynesian Phillips curve. In the Expectations Augmented case it can be thought of as a simple test of whether there is actually any forward-looking element in the OECD forecasts beyond simple adaptive expectations.

Our data set stretches back from 2002 to 1977 after allowing for the lags required in the specification and estimation and covers the twelve euro area countries.[24] It is only possible to use synthetic estimates of the euro area aggregate as that particular grouping of countries was not envisaged ex ante nor indeed agreed until June 2000. We therefore do not do so, although we have illustrated this in Paloviita and Mayes (2003). All information is drawn from the December issues of the OECD *Economic Outlook* (except of course for the June-based data drawn for comparison, where again the June issues are used through out).

To pre-judge our results, all three versions of the (output gap based) Phillips relation do a reasonable job in accounting for inflation dynamics in the euro area. Our specification seems to generate less perverse results from our particular set of European countries than some investigators have found elsewhere. While the hybrid model will always produce the best overall fit, since it includes a lagged dependent variable in a

[23] Similar studies with survey based expectations have been done by Roberts (1997, 1998) for the US economy.

persistent series, if anything, statistical tests using the most recent information (Paloviita and Mayes, 2003) appear to favour the Expectations Augmented approach as an overall explanation in the euro area but the results for the individual countries show no clear pattern, some favouring one, some the other and the rest offering no preference. The difference in slopes of the Phillips curve under all specifications is substantial across the member states, implying that the same output gap would have strikingly different implications for inflation across the euro area. The persistence of both inflation and the output gap, while also showing considerable variation across countries, is not so divergent. However, combining the two factors to show the dynamics of inflation exacerbates the differences both among the member states and between the two models. Incorporating the persistence in the output gap increases the spread of the New Keynesian estimate, as expected. What is particularly notable for the euro area, with both inflation measures, is the more responsive New Keynesian than Expectations Augmented Phillips relation. Moreover, for both of these models under both inflation measures, the influence of the Phillips relationship is stronger than in the case of the euro area in only one of the four largest economies. This offers some explanation for the tensions that seem to have been emerging between the smaller and larger economies in the application of the Stability and Growth Pact.[25] Thus if euro area policy were to be based on our estimates conclusions could be considerably different from those implied by behaviour in individual countries.

Prima facie, therefore, we might expect that pooling the data might lead to a clear rejection of the restrictions. Somewhat surprisingly this is not the case.

5 The Use of Real Time Data in Estimation

Our main results focus on the Hybrid model as this gives a more comprehensive opportunity to consider how forward-looking expectation formation appears to be. It is immediately obvious from Table 2, using the maximum data set available, that the

[24] Some series start later than 1977. In particular, OECD output gap estimates are not available for Luxembourg.

[25] There are several examples where the Phillips curve seems to be rather flat. Rudd and Whelan (2001) caution against some sources of bias in estimating the New Keynesian Phillips curve that may generate results of this sort through misspecification and poor instruments. We address this point later.

balance of expectations formation falls slightly in the forward-looking direction.[26] The successive rows, 1 - 4 and 5 - 8, show the effect of adding more real time information, for each of the GDP deflator (GDP) and consumers' expenditure deflator (CP) measures of inflation. Rows 1 and 5, which provide the starting point, with just the OECD forecasts included as the measure of expectations can be contrasted with rows 9 and 11 which show the effect of estimating the model using the actual outcome the following year on, on the basis of the most recently revised data (December 2003 *Economic Outlook*).[27] The difference is surprisingly small despite the relatively low accuracy of the forecasts recorded in Table 1. Adding the real time estimate of lagged inflation makes relatively little difference but using our constructed real time estimate of the output gap with an HP filter leads to the well-known problem discussed above of obtaining a wrong-signed coefficient (Galí and Gertler, 1999). Given the rather poor determination of the output gap coefficients in any case, this should perhaps be no surprise. Expressing current inflation in real time terms, which is also an OECD forecast in that it is the estimate of the current year published in December but in effect based on only two quarters official estimates, increases the forward-looking weight considerably. In the consumers' expenditure case the forward-looking weight is now twice the backward-looking weight. As each item of real time information is added to the picture so the forward-looking component increases in importance. To some extent price setters appear to be able to take account of information that was not in the currently published data but was incorporated in the revised information after the event.

[26] In Table 2 we have used OECD inflation forecasts since 1977 with the exception of Luxembourg and Portugal, where forecasts are only available from 1982 and 1980, respectively. This gives a total of 304 observations and not the 312 that would stem from a full balanced panel. As noted earlier, there is one discrepancy from the principle of being to use just a single data source. The second lags of real time inflation rates for 1977-1985 to be used as instruments are not available in *Economic Outlook* and were collected instead from OECD *National Accounts*. For Germany, France and Italy additional information is needed only for the years 1977-1983.

[27] Rows 10 and 12 show instrumental variables estimates using a second lag on inflation and a lag on the output gap as instruments.

Table 2: Estimates of restricted Hybrid model with HP filtered output gap and real time data, LS with Newey-West correction

row	Model	weight	s.e.	Coeff	s.e.	DW	SEE	Rsqr	N
1	*GDP, exp*	0.557	0.03	0.014	0.03	2.39	1.459	0.934	304
2	*GDP, exp, plag-realt*	0.551	0.04	0.018	0.04	2.04	1.465	0.933	304
3	*GDP, exp, plag-realt realtgap*	0.560	0.03	-0.028	0.06	2.04	1.465	0.933	304
4	*Real tGDP, exp, plag-realt*	0.602	0.02	-0.098	0.03	2.13	1.107	0.960	304
	Realtgap								
5	*CP, exp*	0.567	0.02	0.070	0.03	1.95	1.100	0.962	304
6	*CP, exp, plag-realt*	0.584	0.03	0.064	0.03	1.74	1.167	0.957	304
7	*CP, exp, plag-realt*	0.613	0.03	-0.044	0.04	1.67	1.176	0.957	304
	Realtgap								
8	*RealtCP, exp, plag-realt*	0.672	0.02	-0.138	0.03	1.84	1.146	0.960	304
	Realtgap								
9	*GDP, plead*	0.527	0.02	0.007	0.02	2.99	1.530	0.927	304
10	*GDP, plead, 2sls*	0.496	0.06	0.109	0.03	2.95	1.550	0.925	304
11	*CP, plead,*	0.517	0.01	0.011	0.02	2.43	1.190	0.956	304
12	*CP, plead, 2sls*	0.522	0.04	0.116	0.04	2.36	1.220	0.953	304

Notes to Tables 2 - 7

EA: Expectations Augmented; *NK*: New Keynesian, *GDP*: GDP deflator; *CP*: consumers' expenditure deflator. The following notation explains which series have been used in the model - *exp*: OECD forecast of inflation; *plag-realt*: real time prices for previous year; *plead*: most recent estimate of prices in next year; *plag*: most recent estimate of prices in previous year; *realtgap*: real time output gap estimates; *realtinstr*: real time instruments in GMM; *realtGDP*, real time GDP deflator; *realtCP*: real time estimate of consumers' expenditure deflator; *OECDgap*: OECD estimate of output gap (using production function method).

As we noted earlier it is unfortunate that we have to estimate a rather crude real-time measure of the output gap. Constructing some more elaborate multivariate estimate using real time data would increase the scale of the exercise substantially. While the OECD itself has computed estimates of the output gap using the production function method, these are only available in real time, i.e. in published forecasts, since 1994. They have calculated output gaps using that method back to the beginning of our sample period but that uses revised data so it does not help for our concern of only using

information available at the time. The result of course is a heavily truncated sample of only 99 observations (Table 3).

Table 3: Estimates of restricted Hybrid model with OECD output gap and real time data, LS with Newey-West correction

row	Model	weight	s.e.	Coeff	s.e.	DW	SEE	Rsqr	N
1	*GDP, exp*	0.689	0.03	0.015	0.01	2.29	0.991	0.750	99
2	*GDP, exp, plag-realt*	0.705	0.04	-0.000	0.01	2.00	1.015	0.738	99
3	*GDP, exp, plag-realt*	0.697	0.06	0.013	0.02	2.02	1.015	0.738	99
	Realtgap								
4	*RealtGDP, exp, plag-realt*	0.733	0.04	-0.020	0.02	2.41	0.589	0.896	99
	Realtgap								
5	*CP, exp*	0.501	0.03	0.094	0.01	1.75	0.583	0.891	99
6	*CP, exp, plag-realt*	0.555	0.04	0.069	0.01	1.50	0.655	0.863	99
7	*CP, exp, plag-realt*	0.581	0.05	0.040	0.02	1.41	0.672	0.855	99
	Realtgap								
8	*RealtCP, exp, plag-realt*	0.582	0.04	0.071	0.02	2.08	0.547	0.902	99
	Realtgap								
9	*GDP, plead*	0.481	0.03	0.060	0.02	3.15	1.082	0.703	99
10	*GDP, plead, 2sls*	0.466	0.06	0.088	0.02	3.13	1.084	0.701	99
11	*CP, plead,*	0.455	0.02	0.077	0.01	2.62	0.592	0.888	99
12	*CP, plead, 2sls*	0.475	0.03	0.086	0.01	2.60	0.594	0.887	99

See notes to Table 2

In this case the weights are slightly different with forward-looking element in the consumers' expenditure deflator case being only a little above half while the GDP deflator sample gives a weight of two-thirds and above. Both are notably higher than what is observed if we use the most recent revised data. This is, of course, not a matched comparison as the sample in Table 2 is much longer. However, if we use the shorter sample but the crude HP-filtered estimates for the shorter sample (Table 4), the same pattern as for the OECD output gap estimates is observed, although the weights using the GDP deflator are not so large. There is therefore some difference in behaviour

in the two data periods. Inflation has been clearly lower since 1994 and therefore in some senses easier to predict. However, it has also become more persistent, so it is not immediately obvious what the effect of this would be on the resultant estimates. Nevertheless it remains that real time data are able if anything to explain inflation a little better and have a noticeably larger forward-looking element in the explanation, in no case lower than the backward-looking weight.

Table 4: Estimates of restricted Hybrid model with HP filtered output gap and real time data, LS with Newey-West correction, short sample (Luxembourg excluded)

Row	Model	weight	s.e.	Coeff	s.e.	DW	SEE	Rsqr	N
1	*GDP, exp*	0.672	0.03	0.057	0.02	2.34	0.985	0.753	99
2	*GDP, exp, plag-realt*	0.686	0.04	0.038	0.02	2.03	1.012	0.740	99
3	*GDP, exp, plag-realt realtgap*	0.627	0.04	0.259	0.04	2.11	0.967	0.762	99
4	*realtGDP, exp, plag-realt realtgap*	0.710	0.02	0.035	0.03	2.41	0.589	0.896	99
5	*CP, exp*	0.518	0.03	0.132	0.01	1.82	0.563	0.898	99
6	*CP, exp, plag-realt*	0.562	0.03	0.111	0.01	1.56	0.636	0.870	99
7	*CP, exp, plag-realt realtgap*	0.530	0.03	0.233	0.03	1.65	0.618	0.878	99
8	*realtCP, exp, plag-realt realtgap*	0.585	0.03	0.142	0.03	2.08	0.535	0.906	99

See notes to Table 2

4.1 Expectations Augmented and New Keynesian Models

The estimation results for the Expectations Augmented and the New Keynesian Phillips curve with both inflation measures and HP filtered output gaps are all summarised in Table 5.[28] In the first four Rows of Table 5 real time information is used only in the expectations variables. It is clear from Table 5 that all four models offer reasonable estimates of the impact of the output gap on inflation when OECD forecasts

[28] Appendix Table 3 shows the results from using just OECD *Economic Outlook*, which limits the estimation period to 1986-2002 with the exception of France, Germany and Italy, the sample of which is 1984-2002.

are used, although in one case the coefficient is not very well determined and in another there is some evidence of autocorrelation. The worry of obtaining a negative coefficient in the New Keynesian case has not materialised. With both inflation measures the standard error of regression is smaller for the Expectations Augmented than the New Keynesian specification. This confirms the results obtained in Paloviita and Mayes (2003) using a shorter data set, 1984-2002, for each of the euro area countries excluding Greece and a synthetic estimate of the euro area.

Table 5: Phillips Curve estimates, GMM, Output gap coefficients, constrained prices

Row	Model	coeff	s.e.	J stat	DW	SEE	N
1	*EA, GDP, exp*	0.070	0.065	0.016	1.58	1.744	304
2	*EA, CP, exp*	0.150	0.050	0.022	1.59	1.676	304
3	*NK, GDP, exp*	0.190	0.086	0.047	1.20	2.059	304
4	*NK, CP, exp*	0.164	0.059	0.064	1.04	1.718	304
5	*EA, GDP, plag-realt*	0.225	0.086	0.020	1.83	2.053	304
6	*EA, CP, plag-realt*	0.235	0.080	0.040	1.63	1.890	304
7	*EA, GDP, plag*	0.147	0.077	0.068	2.20	2.082	304
8	*EA, CP, plag*	0.286	0.074	0.053	1.67	1.841	304
9	*NK, GDP, plead*	0.058	0.080	0.052	2.07	2.060	304
10	*NK, PC, plead*	0.066	0.064	0.050	1.44	1.920	304
11	*EA, GDP, exp, realtgap*	-0.256	0.182	0.020	1.52	1.816	304
12	*EA, CP, exp, realtgap*	0.082	0.119	0.036	1.51	1.712	304
13	*NK, GDP, exp, realtgap*	-1.320	0.304	0.015	1.08	2.402	304
14	*NK, CP, exp, realtgap*	-1.027	0.232	0.032	1.01	1.794	304
15	*EA, GDP, exp, realtinstr*	0.034	0.091	0.015	1.56	1.743	304
16	*EA, CP, exp, realtinstr*	0.209	0.070	0.022	1.59	1.681	304
17	*NK, GDP, exp, realtinstr*	0.167	0.094	0.050	1.21	2.032	304
18	*NK, CP, exp, realtinstr*	0.300	0.082	0.054	0.98	1.854	304
19	*EA, GDP, exp, realtgap, realtinstr*	-0.078	0.120	0.016	1.55	1.761	304
20	*EA, CP, exp, realtgap, realtinstr*	0.115	0.090	0.035	1.50	1.713	304
21	*NK, GDP, exp, realtgap, realtinstr*	-0.221	0.155	0.052	1.36	1.879	304
22	*NK, CP, exp, realtgap, realtinstr*	-0.628	0.182	0.050	1.18	1.567	304
23	*EA, realtGDP, exp, realtgap, realtinstr*	0.009	0.067	0.023	1.72	1.511	304
24	*EA, realtCP, exp, realtgap, realtinstr*	0.100	0.087	0.029	1.50	1.805	304
25	*NK, realtGDP, exp, realtgap, realtinstr*	-0.574	0.192	0.051	1.29	1.575	304
26	*NK, realtCP, exp, realtgap, realtinstr*	-0.596	0.167	0.063	1.37	1.442	304

See notes to Table 2.

These results are worth considering a little further as we do not investigate the estimates at the individual country level in the present paper. Overall, the estimation results using the GDP deflator in Paloviita and Mayes (2003) (shown in Appendix Table 1) are fairly plausible for the euro area and for individual economies. The estimated output gap normally enters with a positive sign in the Expectations Augmented model but values and significance levels are low for the individual countries and the euro area. In the New Keynesian specification the coefficient on the output gap is positive for the euro area and for eight out of eleven countries. The estimated coefficients on the output gap are lower in the Expectations Augmented specification for the euro area but there is

much more variability for the individual countries. Hence, for the aggregate euro area, inflation appears to be less sensitive to changes in current excess demand, when expectations are measured by the inflation forecast for the current year instead of the inflation forecast for the next year. This effect is increased by the excess demand effect incorporated in expected future inflation. The statistical reliability of the output gap coefficients is greater in the New Keynesian specification for the euro area.

The results are slightly different, when using the private consumption deflator as the measure of inflation, as shown in Appendix Table 2. All the estimated output gap coefficients are positive in the Expectations Augmented specification and there are only two estimates with the wrong sign in the New Keynesian case. In this case the two models give the same value for the output gap coefficient for the euro area, although the Expectations Augmented specification is more satisfactory statistically. In general the results using the private consumption deflator are better determined than those with the GDP deflator, which is fortunate since the former is the closer approximation to the policy variable.

In the foregoing we have simply shown that the use of OECD forecasts of inflation gives plausible estimates of the Phillips curve under both the Expectations Augmented and the New Keynesian specifications. In particular, it avoids the perverse sign on the output gap that tends to be observed in the New Keynesian model (Galí and Gertler, 1999). However, this is only part of the argument with respect to the present dataset as it gives no comparator. The simplest comparator is to use actual values as estimated in the most recent (December 2003) OECD *Economic Outlook* as extreme versions of expectations formation. Thus if we use lagged inflation in the Expectations Augmented model, this is equivalent to adaptive expectations.[29] In the New Keynesian model we can go in the opposite direction and use a single lead on inflation as the comparator of year *t*'s forecast of year $t + 1$. If we include lagged inflation in the New Keynesian model as an additional variable, it turns into the specification of the Galí and Gertler (1999) Hybrid model, and this is already considered in our analysis.

If we compare the EA and NK models using OECD forecasts with their naïve equivalents (Rows 7-10 of Table 5), the standard error of regression is in seven out of

eight cases higher when using final data than to that of using forecasts. In the Expectations Augmented case the coefficients increase in size.[30] Since it is possible to do, we also explored what happens if we use real time data for the inflation variables in the EA case (Rows 5 and 6). The real time data in this case are the published estimates of inflation the previous year, which would have been known at the time. (Clearly the same cannot be done for the NK model as the lead can never be known in real time.) When measuring inflation with the private consumption deflator in the EA model, the result lies between the two, although it is nearer to the naïve model using final data than to that using the forecasts. With the GDP deflator we get the highest slope of the Phillips curve when lagged real time data are used. There is thus some limited evidence here in favour of use of real time data. The slope of the New Keynesian Phillips curve becomes smaller and more weakly determined, when OECD forecast is replaced with the corresponding final leaded inflation rate. All in all this clearly confirms our earlier suggestion that the use of real time forecasts as a measure of expectations is an assistance to the estimation of the Phillips curve.

The simplest extension to consider (Table 5 Rows 11-14) is to replace the output gap by its real time equivalent. As noted above, there is a widespread choice of the representation to use for the gap variable and our results illustrate only one of them. The variation among different measures of the output gap using the same data may very well be greater than variation among the same measure using different data sets, so this cannot be a test of the general hypothesis. However, in this case the effect is striking. In no case do we now obtain an output gap estimate that is a plausible size and significantly greater than zero at even the 10 percent level. In the New Keynesian case, the output gap coefficient is indeed quite well determined under both price specifications but firmly negative. The fit of the equations is similar.[31]

The explanation of the difference between the two samples could lie in the either length of the data period available for calculating real time output gaps in the early

[29] Since the actual outcome of last year's expectation of this year's inflation is the dependent variable that will clearly not do as a basic hypothesis against which to test the model.

[30] The results are rather different in the shorter sample shown in Appendix Table 2. A simple explanation would be that the early years that are omitted are ones of both higher inflation and higher inflation variance, which would make forecasting rather more difficult and hence likely to lie inside the actual variance (see Figure 5 as an example).

years (only around 20 observations) or in the degree of revision of the series. A real time output gap using the HP filter in our sense involves a substantial change from the method with the most recently published series. We have not only changed the GDP data series from the most recent estimates to 'real time' but we have recomputed the output gaps using the real time data out to the end of the forecast period on each occasion, thus harshening the end point problem each time. In the most recent data only the last period, 2002, suffers from having only two further (forecast) values from which to compute the trend. Each earlier observation uses one more year as we go back towards the start of the data. It is in principle possible to explore what happens if the output gap is computed in a comparable way. We can either use the most recent data but only include two leads in the computation or we can use the entire real time GDP series to compute the gap. We could also use different methods for projecting further forward so as to reduce the end point problem, shown by Figure 3.

Clearly the real time estimates are a more realistic estimate of what was available to make a computation at the time. However, of course there is no suggestion that price setters actually computed the gap that way. We can take the analysis one step further by using the OECD's own estimates of the output gap using the production function method. (They do not cover Luxembourg.) In this case the sample has to be much smaller. However, the OECD has calculated output gaps right back to the beginning of our sample period using revised data.[32] This at least should be the output gap estimate that is consistent with OECD's forecasts of inflation. In so far as their estimates of the output gap were used in the computation of their forecasts then there will be correlated errors in the two variables. This might help explain the perversity in the coefficients shown in Table 6, which reworks the first four lines of Table 5 using these new estimates. We now observe that three out of the four estimates have the wrong sign and all are rather poorly determined. This is rather ironic as we anticipated that this would be a rather better estimator of the output gap. If on the other hand either the most recent or real time estimates of lagged inflation are used in the Expectations Augmented

[31] In the short sample, Appendix Table 3, the output gap coefficients all increase in size but their significance falls along with the explanatory power of the equation as a whole.

[32] The short sample estimates relate to the period from 1994 onwards when real time estimates of the output gap by the OECD have been available. A long sample can be used when the most recent estimates are the only ones included, as the OECD has published its estimates of the output gap right back to the beginning of our forecast period, 1977.

specification then the results are of a reasonable sort of order and modest significance. In general therefore the ability of these output gap estimates to explain inflation appears fatally flawed.

Perhaps, however, this is not a fair test and what we ought to be considering is how well the use of real time data is in explaining the first published estimates of actual inflation. Since we do not have lagged values of inflation in the specification, it is not that the explanation is improved because of a better representation of the inertia in the series. Put crudely, we can certainly suggest that the OECD appears to be better at forecasting the first estimates of inflation than it has been in forecasting the final estimates. This seems inherently plausible, especially since much of inflation for the current year would already have been known. At least this is a better representation of what one group of decision-makers was doing. However, our concern is with the population of price setters, not just a group of forecasters. The 'real time' estimate of inflation here, in the sense of the first estimate officially published, is in the view of the statistical authorities a worse estimate than the most recent one, which is the best they think they can achieve at present on the information they have available. Hence this real time approach to the output gap is not an obviously improved means of explaining their actions. Only using the real time OECD forecast as a measure of expectations seems to help.

Table 6: Phillips curves using OECD output gap estimates

Row	Model	coeff	s.e.	J stat	DW	SEE	N
1	*EA, GDP, exp, OECDgap*	-0.010	0.063	0.015	1.52	1.626	277
2	*EA, CP, exp, OECDgap*	0.022	0.043	0.027	1.35	1.552	277
3	*NK, GDP, exp, OECDgap*	-0.101	0.082	0.054	1.35	1.851	277
4	*NK, CP, exp, OECDgap*	-0.120	0.064	0.070	1.10	1.544	277

See notes to Table 2

All in all, moving on to the use of real time estimates of the output gap is again not very promising. This could of course be due to the very short sample. Although by pooling the euro area countries we obtain a larger data set, they still provide only nine observations each. While this does cover a cycle it might very well be that a longer sample would be more informative. Nevertheless these estimates incline us towards the less optimistic end of the spectrum over the value of simple functional forms.

Elsewhere, (Mayes and Virén, 2002) we have shown that the Phillips curves for the euro area countries are clearly asymmetric in that the output gap coefficient is different when the gap is positive from when it is negative. In those results, using the Expectations Augmented framework, we find that the coefficient for a positive output gap is clearly positive, while that for a negative gap is near zero and the estimates are not significantly different from zero even at the 10 percent level. Omitting this asymmetry and indeed other variables may account for these weak results (we include import (foreign) prices in the Mayes and Virén (2002) specification, along with a more complex lag structure). The addition of such lags and other variables is common in empirical models, However, the more backward-looking we make the model, the less the real time issues we have been considering will tend to be important.

6 Real Time Instruments

In this final section we move on to consider the use of real time data for the instruments in GMM estimation. This aspect can be examined using a database that contains real time variables, not just for current values but also lagged information that was available at the time. When real time information is used in the expectations variable, it is logical to choose a common data set so that the instruments are also what were available at the time instead of final variables. As Orphanides (2001) points out, decision makers have to use noisy data without knowing what the noise is. If we use instruments without the noise then they may be correlated with the errors. They will also not be so well correlated with the omitted relationship, such as the setting of monetary policy.

In the Hybrid model, Table 7, using the lagged output gap and the second lag on inflation as instruments, the immediate effect is to reduce the forward-looking weight considerably.[33] However, at the same time the slope of the Phillips curve steepens considerably. In commenting on the conference version of the paper, Orphanides argued that this is exactly what one would expect if monetary policy is also forward-looking and is captured by expectations. Since there is some doubt whether the normalisation used is the most suitable (Søndergaard, 2003) this may help the higher backward-

[33] This is a considerably smaller instrument set than used in Søndergaard (2003) or indeed in Galí and Gertler (1999) both in terms of range of variables and number of lags.

looking weight. In any case as Goodfriend and King (2001) point out there will be a degree of persistence observed in the data even if the decision-making process itself is entirely forward-looking. Indeed, it is important not to misinterpret the implications of empirical lags as suggesting that a less forward-looking monetary policy should be employed.

As shown in Rows 15-18 in Table 5, for both EA and NK specifications with the GDP deflator the slope of the Philips curve becomes lower and less precise, when real time variables are used as instruments instead of final variables. The opposite is true with the private consumption deflator. Real time instruments seem to matter in the Phillips relation, when real time data is used also to measure inflation expectations. When the revised inflation rate is explained by using real time data for all right hand side variables and instruments (see Rows 19-22 in Table 5) or alternatively, throughout the equations (Rows 23-26), many of the results show negative slope coefficients.

Overall, what is clear is that using real time instruments does have an effect. It would be inappropriate to ignore the appropriate choice of real time as opposed to most recent data for instruments as it has a material effect on the estimates. Different results in Table 5 and Appendix Table 3 may be due to price developments in the euro area economies since the mid-1970s. In the beginning of the long sample inflation was at a high level in many countries, but it decreased rapidly to a clearly lower level during the first half of the 1980s. In spite of a small peak in the beginning of the 1990s, inflation has remained subdued in the euro area countries. In addition, quite diverse developments in the output gaps may explain implausible results in Appendix Table 3.

Table 7: Estimates of the hybrid model, GMM

Row	model	Weight	s.e.	Coeff	s.e.	J stat	DW	SEE	N
1	*GDP, exp*	0.37	0.06	0.110	0.046	0.003	2.56	1.541	304
2	*CP, exp*	0.39	0.05	0.211	0.041	0.000	2.02	1.214	304
3	*GDP, plead*	0.50	0.06	0.107	0.034	0.000	2.95	1.549	304
4	*CP, plead*	0.51	0.06	0.121	0.035	0.000	2.36	1.220	304
5	*GDP, exp, realtinstr*	0.37	0.06	0.121	0.074	0.001	2.55	1.539	304
6	*CP, exp, realtinstr*	0.37	0.06	0.310	0.074	0.001	1.89	1.280	304
7	*GDP, exp, plag-realt*	0.31	0.09	0.129	0.088	0.001	2.10	1.588	304
	Realt-instr								
8	*CP, exp, plag-realt*	0.34	0.07	0.312	0.083	0.000	1.76	1.380	304
	Realt-instr								
9	*GDP, exp, plag-realt*	0.19	0.18	0.283	0.208	0.000	1.92	1.756	304
	Realt-instr, realtgap								
10	*CP, exp, plag-realt*	0.13	0.15	0.557	0.217	0.005	1.61	1.673	304
	Realt-instr, realtgap								
11	*RealtGDP, exp, plag-realt, realt-instr, realtgap*	0.22	0.15	0.318	0.172	0.000	1.793	1.510	304
12	*RealtCP, exp, plag-realt*	0.18	0.15	0.490	0.211	0.004	1.605	1.680	304
	Realt-instr, realtgap								

See notes to Table 2.

7 Concluding remarks

The foregoing analysis examines the use of real time information in the Phillips curve relationships. The focus has been on the usefulness of real time information in the Expectations Augmented, the New Keynesian and the Hybrid model. As economic decisions are always based on imperfect information at the time without the benefit of hindsight, our motivation has been to use real time information in the expectations variable in the Phillips relation instead of up to date most recent revised estimates of variables. More specifically, OECD forecasts have been used as a proxy for inflation

expectations. Also, by using a complex database, real time information in other variables and instruments under GMM have been examined. The usefulness of real time information in the Phillips curve is particularly interesting in the euro area, as the European Central Bank, conducting a single monetary policy, has to cope with different price developments in the twelve member states.

A number of conclusions can be drawn on the basis this study. First of all, using real time information on expectations, in the form of forecasts – in this case those published by the OECD – does seem to act as an improvement over some simple adaptive or rational expectations approaches in estimating Phillips curves for the euro area countries in the period since the mid-1970s. In particular it seems to help overcome the common result with the New Keynesian specification of obtaining a negative relationship with the output gap.

Secondly, using real time data in the model offers a marginal improvement to the explanation, although the principal means of estimating the output gap used, namely, an HP filter creates difficulties of its own, not least through the end point problem. Rather disappointingly, using the OECD's own estimates of the output gap, which are available for only a short period, but can be incorporated because we use pooled data for the (eleven) euro area countries (excluding Luxembourg), produces poor results in any almost any specification.

The most striking result, however, is that using real time data increases the apparent forward-looking weight as indicated by the Hybrid model. This confirms the results found for other countries, Orphanides (2001) for the United States and Huang et al. (2001) for New Zealand for example. In real time people do try to take into account other information about what is happening and likely to occur, which is not in the currently published statistics. After the event those statistics themselves can be revised as some of that extra information is revealed and any inconsistencies in the series become apparent. Thus using revised data the forward-looking element will be reduced.

Lastly we explored whether using real time instruments in the GMM estimation of the Phillips curve appears to matter. It appears that there is a small improvement in the ability to explain inflation using the real time instruments. Interestingly, when looking at the estimation results for the Expectations Augmented and the New Keynesian

Phillips curves with both inflation measures, in three out of four cases, the standard error of regression is lowest, if real time information is used throughout the equations. In the Hybrid model, the use of information affects the relative weight of the forward looking expectations. Although the estimation results are sensitive to the choice of the forcing variable and the output gaps, which are based on HP filtering, suffer from end point problems, we can say that the use of real time information makes a noticeable difference when explaining inflation dynamics. Revisions in this data set, even in the price series, are sufficient to matter.

Appendix Table 1: Single equation estimation results using the GDP deflator as the measure of inflation

Expectations-augmented specification

$$\pi_t = E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

	Parameters			Tests
	λ			J
EU 11	0.059	(0.101)		0.037
Austria	0.299	(0.209)		0.094
Belgium	0.177	(0.174)		0.005
Finland	0.090	(0.101)		0.032
France	–0.054	(0.092)		0.037
Germany	0.015	(0.084)		0.016
Ireland	0.020	(0.109)		0.022
Italy	0.011	(0.483)		0.118
Luxembourg	0.178	(0.160)		0.013
Netherlands	0.198	(0.136)		0.048
Portugal	–0.105	(0.125)		0.140
Spain	0.493	(0.147)	*	0.165

New Keynesian specification

$$\pi_t = 0.97 \cdot E_t\{\pi_{t+1}\} + \kappa \hat{y}_t$$

	Parameters			**Tests**
	κ			**J**
EU 11	**0.219**	**(0.107)**	*****	**0.142**
Austria	0.199	(0.106)		0.041
Belgium	–0.041	(0.155)		0.064
Finland	0.032	(0.055)		0.006
France	–0.031	(0.085)		0.059
Germany	0.158	(0.130)		0.001
Ireland	–0.017	(0.138)		0.107
Italy	1.070	(0.273)	*	0.209
Luxembourg	0.064	(0.079)		0.001
Netherlands	0.264	(0.278)		0.000
Portugal	0.675	(0.409)		0.148
Spain	0.571	(0.199)	*	0.192

Notes: Sample period 1984–2002. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to the Hansen test of the overidentifying restrictions. The J-statistic times the number of observations is asymptotically χ^2 with one degrees of freedom, the critical value of which is 3.84. Instrument: the lagged output gap, $\hat{y}_{t-1}$.

Appendix Table 2: Single equation estimation results using the private consumption deflator as the measure of inflation

Expectations-augmented specification

$\pi_t = E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$

	Parameters			Tests
	λ			J
EU 11	0.233	(0.060)	*	0.049
Austria	0.419	(0.211)		0.036
Belgium	0.134	(0.308)		0.011
Finland	0.111	(0.086)		0.107
France	0.117	(0.062)		0.012
Germany	0.102	(0.048)	*	0.058
Ireland	0.035	(0.083)		0.006
Italy	0.771	(0.163)	*	0.189
Luxembourg	0.280	(0.071)	*	0.008
Netherlands	0.207	(0.144)		0.006
Portugal	0.425	(0.194)	*	0.048
Spain	0.356	(0.115)	*	0.192

New Keynesian specification

$\pi_t = 0.97 \cdot E_t\{\pi_{t+1}\} + \kappa \hat{y}_t$

	Parameters			Tests
	κ			J
EU 11	0.240	(0.130)		0.217
Austria	0.394	(0.108)	*	0.001
Belgium	–0.068	(0.109)		0.011
Finland	0.229	(0.064)	*	0.158
France	0.162	(0.072)	*	0.142
Germany	0.338	(0.063)	*	0.020
Ireland	0.025	(0.066)		0.153
Italy	0.909	(0.338)	*	0.231
Luxembourg	0.149	(0.048)	*	0.172
Netherlands	0.144	(0.235)		0.022
Portugal	0.457	(0.228)	*	0.198
Spain	–0.731	(0.272)	*	0.148

Notes: See Appendix Table 1.

Appendix Table 3. Phillips Curve estimates – short sample, GMM, Output gap coefficients, constrained prices

row	Model	coeff	s.e.	J stat	DW	SEE	N
1	*EA, GDP, exp*	0.010	0.055	0.022	1.50	1.429	210
2	*EA, CP, exp*	0.124	0.036	0.019	1.41	1.063	210
3	*NK, GDP, exp*	0.154	0.078	0.053	1.08	1.795	210
4	*NK, CP, exp*	0.160	0.050	0.053	0.83	1.505	210
5	*EA, GDP, plag-realt*	0.000	0.078	0.039	1.88	1.836	210
6	*EA, CP, plag-realt*	0.090	0.056	0.045	1.62	1.351	210
7	*EA, GDP, plag*	-0.055	0.060	0.059	2.32	1.893	210
8	*EA, CP, plag*	0.103	0.052	0.071	1.73	1.396	210
9	*NK, GDP, plead*	0.183	0.065	0.034	2.05	1.944	210
10	*NK, PC, plead*	0.054	0.045	0.041	1.53	1.356	210
11	*EA, GDP, exp, realtgap*	0.022	0.219	0.022	1.50	1.427	210
12	*EA, CP, exp, realtgap*	0.446	0.134	0.022	1.23	1.166	210
13	*NK, GDP, exp, realtgap*	0.402	0.315	0.053	1.05	1.803	210
14	*NK, CP, exp, realtgap*	0.592	0.212	0.045	0.74	1.706	210
15	*EA, GDP, exp, realtinstr*	-0.053	0.081	0.023	1.45	1.439	210
16	*EA, CP, exp, realtinstr*	0.111	0.045	0.021	1.40	1.050	210
17	*NK, GDP, exp, realtinstr*	0.187	0.092	0.052	1.06	1.817	210
18	*NK, CP, exp, realtinstr*	0.257	0.070	0.047	0.80	1.598	210
19	*EA, GDP, exp, realtgap, realtinstr*	-0.145	0.160	0.021	1.44	1.462	210
20	*EA, CP, exp, realtgap, realtinstr*	0.237	0.095	0.021	1.30	1.083	210
21	*NK, GDP, exp, realtgap, realtinstr*	0.291	0.168	0.060	1.08	1.751	210
22	*NK, CP, exp, realtgap, realtinstr*	0.389	0.148	0.051	0.78	1.561	210
23	*EA, realtGDP, exp, realtgap, realtinstr*	-0.031	0.083	0.031	1.60	1.065	210
24	*EA, realtCP, exp, realtgap, realtinstr*	0.142	0.081	0.019	1.69	0.996	210
25	*NK, realtGDP, exp, realtgap, realtinstr*	0.195	0.181	0.069	0.81	1.448	210
26	*NK, realtCP, exp, realtgap, realtinstr*	0.213	0.116	0.048	0.80	1.254	210

Notes to Appendix Table 3
EA: Expectations Augmented; *NK*: New Keynesian, *GDP*: GDP deflator; *CP*: consumers' expenditure deflator. The following notation explains which series have been used in the model - *exp*: OECD forecast of inflation; *plag-realt*: real time prices for previous year; *plead*: most recent estimate of prices in next year; *plag*: most recent estimate of prices in previous year; *realtgap*: real time output gap estimates; *realtinstr*: real time instruments in GMM; *realtGDP*, real time GDP deflator; *realtCP*: real time estimate of consumers' expenditure deflator; *OECDgap*: OECD estimate of output gap (using production function method).

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