Economics Department

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Abstract

In this paper we examine some of the issues which will arise if the European Central Bank adopts "direct inflation" targeting after the adoption of the single currency in Europe. One issue is how big the deviations in national inflation rates from the European average might be. Another is the definition of the inflation rate to be targeted.

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1 Introduction

In its report on the question of operating procedures and strategies for the European Central Bank in Stage Three of monetary union, the European Monetary Institute (1997) considered five possible strategies; rejecting three of them (exchange rate targeting, interest rate targeting and nominal income targeting), it narrowed the field to monetary and "direct" inflation targeting. The authors of the report went on to consider a number of critical features of inflation targeting, including its use of a wide information set, the fact that it relates directly to the ECB's principal statutory task, and the possibility that there might be a structural break in the forecasting relationships and policy derivatives that the ECB would need to be able to rely upon if it adopted the strategy. The report calls for further research to be undertaken into various aspects of an inflation targeting strategy.

This paper concerns itself with a modest and preliminary exploration of some of the questions that need to be answered. As a framework within which to pose these questions we adapt a model suggested by Svennson (1966). This is set out in the next section of the paper. There has been a good deal of academic work on the nature of direct inflation targeting and its relative merits, within the paradigm of the reputation and credibility model first proposed by Barro and Gordon (1983) and extended more recently by Walsh (1995) and others, where the issue of the optimal contract design for a central banker charged with the control of inflation has been discussed. We briefly revisit these questions in the last section of the paper.

The intervening sections of the paper are concerned with some issues which can be resolved, or at least illuminated, by empirical work. One issue is how big the deviations in national inflation rates from the European average might be; we provide some evidence of this in section 3. Another issue is the definition of the inflation rate to be targeted; in this context some observers have suggested use of the notion of "core inflation"; in section 4 of the paper we provide alternative measures of core inflation for the European countries, using data supplied by Eurostat and we compare these measures with actual (CPI) inflation. In the same section we consider the issue of forecastability. Finally we present some conclusions in section 5.

2 Inflation Targeting: A perfect model

We may suppose that we are dealing with two countries which have decided to form a currency union, adopting a single currency. After the union there is a single monetary instrument i^{eu} and one inflation target π^{*}. The two countries, denoted by superscripts h, f (home and foreign) consume and produce two groups of commodities, group 1 and 2, which make up the consumer price index. Later on, we identify these as traded and non-traded goods. For the time being, however, we do not employ this distinction. The two countries run independent fiscal policies and face symmetric price (demand) shocks.

Total EU output relative to trend will be given by:

$$y_t^{eu} = \kappa y_t^h + (1-\kappa) y_t^f \tag{1}$$

2.1 Inflation

In country h the inflation rates for the two groups of goods or services are given by:

$$\begin{aligned} \pi_{1,t+1}^h &= \pi_{1,t}^h + \alpha_1 y_t^h + \alpha_2 x_t + \varepsilon_{1,t+1} \\ \pi_{2,t+1}^h &= \pi_{2,t}^h + \alpha_1 y_t^h + \alpha_2 x_t + \varepsilon_{2,t+1} \end{aligned}$$

Average inflation in the home country h will be given by:

$$\pi_{t+1}^h = w_h \pi_{1,t+1}^h + (1-w_h)\pi_{2,t+1}^h$$

Similarly in country f we allow for the same responses of inflation to output deviations from trend and an exogenous variable:

$$\begin{aligned} \pi_{1,t+1}^f &= \pi_{1,t}^f + \alpha_1 y_t^f + \alpha_2 x_t + \varepsilon_{1,t+1} \\ \pi_{2,t+1}^f &= \pi_{2,t}^f + \alpha_1 y_t^f + \alpha_2 x_t + \varepsilon_{2,t+1} \end{aligned}$$

and inflation in the country f will be given by:

$$\pi_{t+1}^f = w_f \pi_{1,t+1}^f + (1-w_f)\pi_{2,t+1}^f$$

That is, we allow for the same disturbances in the two goods sectors but for different expenditure patterns, which are reflected by the different weights

$w_i, i = h, f$ attached to the two goods in these countries. The two price indices are thus given by:

$$\pi_{t+1}^h = w_h \pi_{1,t}^h + (1 - w_h)\pi_{2,t}^h + \alpha_1 y_t^h + \alpha_2 x_t + \left[w_h \varepsilon_{1,t+1} + (1 - w_h)\varepsilon_{2,t+1}\right]$$

$$\pi_{t+1}^f = w_f \pi_{1,t}^f + (1 - w_f)\pi_{2,t}^f + \alpha_1 y_t^f + \alpha_2 x_t + \left[w_f \varepsilon_{1,t+1} + (1 - w_f)\varepsilon_{2,t+1}\right]$$

The EU-wide inflation rate is given by:

$$\pi_{t+1}^{eu} = \kappa \pi_{t+1}^h + (1 - \kappa)\pi_{t+1}^f$$

and using the above expressions this can be simplified to

$$\pi_{t+1}^{eu} = \pi_t^{eu} + \alpha_1 y_t^{eu} + \alpha_2 x_t + \xi_{t+1} \tag{2}$$

where $\xi_{t+1} = \kappa w_h \varepsilon_{1,t+1} + \kappa(1 - w_h)\varepsilon_{2,t+1} + (1-\kappa) w_f \varepsilon_{1,t+1} + (1-\kappa)(1-w_f)\varepsilon_{2,t+1}$. The weight κ simply reflects the size of country h in the union.

2.2 Output

We also allow for the same vector of exogenous variables x that affect inflation to influence output. This is for simplification, and can be relaxed later. These exogenous variables affect output in each country, though in different degree.

$$\begin{aligned} y_{t+1}^h &= \beta_1 y_t^h + \beta_2 y_t^f - \beta_3(i_t^{eu} - \pi_t^h) + \beta_4 x_t + \eta_{t+1}^h \\ y_{t+1}^f &= \beta_1 y_t^f + \beta_2 y_t^h - \beta_3(i_t^{eu} - \pi_t^f) + \beta_4 x_t + \eta_{t+1}^f \end{aligned}$$

Notice that, given differences between the countries in their inflation rates, the implied real interest rates must differ. Then

$$\begin{aligned} y_{t+1}^{eu} &= \beta_1 y_t^h + \beta_2 y_t^f + \kappa(\beta_1 - \beta_2)(y_t^h - y_t^f) \\ &\quad -\kappa\beta_3(i_t^{eu} - \pi_t^h) - (1 - \kappa)\beta_3(i_t^{eu} - \pi_t^f) + \beta_4 x_t + \eta_{t+1}^{eu} \end{aligned} \tag{3}$$

where $\eta_{t+1}^{eu} = \kappa\eta_{t+1}^h + (1 - \kappa)\eta_{t+1}^f$.

2.3 The Model

When we aggregate, the model looks like this:

$$\begin{aligned}
\pi_{t+1}^{eu} &= \pi_t^{eu} + \alpha_1 y_t^{eu} + \alpha_2 x_t + \xi_{t+1} \\
y_{t+1}^{eu} &= \beta_1 y_t^h + \beta_2 y_t^f + \kappa(\beta_1 - \beta_2)(y_t^h - y_t^f) - \kappa\beta_3(i_t^{eu} - \pi_t^h) \\
&\quad -(1-\kappa)\beta_3(i_t^{eu} - \pi_t^f) + \beta_4 x_t + \eta_{t+1}^{eu} \\
x_{t+1} &= \gamma x_t + \theta_{t+1}
\end{aligned}$$

We can write the expression for π_{t+2}^{eu} in terms of time t variables only:

$$\begin{aligned}
\pi_{t+2}^{eu} &= a_1\pi_t^h + a_2\pi_t^f + a_3 y_t^h + a_4 y_t^f - a_5 i_t^{eu} + a_6 x_t \\
&\quad + \left(\xi_{t+1} + \xi_{t+2} + \alpha_1\eta_{t+1}^{eu} + \alpha_2\theta_{t+1}\right) \qquad (4)
\end{aligned}$$

where $a_1 ... a_6$ are defined in the Appendix.

2.4 Inflation forecasting

The forecast for inflation two periods ahead $\pi_{t+2|t}^{eu}$, based on the model, is simply given by:

$$\pi_{t+2|t}^{eu} = a_1\pi_t^h + a_2\pi_t^f + a_3 y_t^h + a_4 y_t^f - a_5 i_t^{eu} + a_6 x_t \qquad (5)$$

Actual inflation will be given by

$$\pi_{t+2}^{eu} = \pi_{t+2|t}^{eu} + \xi_{t+1} + \xi_{t+2} + \alpha_1\eta_{t+1}^{eu} + \alpha_2\theta_{t+1}$$

and the forecast error is

$$\pi_{t+2}^{eu} - \pi_{t+2|t}^{eu} = \xi_{t+1} + \xi_{t+2} + \alpha_1\eta_{t+1}^{eu} + \alpha_2\theta_{t+1}$$

2.5 "Inflation forecast" targeting, or, why the ECB should make public point forecasts for inflation.

Svensson(1996) shows that if inflation targeting is interpreted as implying that the central bank in period t chooses a sequence of current and future interest rates $\{i_\tau\}_{\tau=t}^{\infty}$ so as to minimize

$$E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t}\frac{1}{2}(\pi_\tau - \pi^*)^2 \qquad (6)$$

the expected sum of discounted squared future deviations from a target π^*, the interest rate each period should be set at a level which implies that the two-year inflation forecast will be equal to the target. In the context of our model this implies a first order condition $\pi^{eu}_{t+2|t} = \pi^*$.

Then using (2.6) and the last result we obtain

$$\pi^* = a_1\pi^h_t + a_2\pi^f_t + a_3y^h_t + a_4y^f_t - a_5i^{eu}_t + a_6x_t$$

which gives the optimal reaction function of the Central Bank

$$i^{eu}_t = b_1\pi^h_t + b_2\pi^f_t - b_3\pi^* + b_4y^h_t + b_5y^f_t + b_6x_t \quad (7)$$

where $b_1...b_6$ are defined in the Appendix. According to this reaction function the ECB will change the interest rate if the forecast for the inflation rate two periods ahead deviates from the announced target. This is a nice result; indeed, it results in a "perfect" inflation targeting model. The Central Bank controls forecasts for inflation. When the forecast deviates from the target, the Central Bank moves the instrument. In these circumstances - and assuming that there is perfect information about the forecasts - the Central Bank can be held accountable for deviations of "inflation forecasts" from the target, not deviations of actual inflation from target. Even according to the model there are unforecastable components which a Central Bank cannot be held accountable for failing to predict. According to this model, then, it is essential - if one is to judge whether the ECB is doing its job when inflation targeting - that it should identify the inflation forecasts which guide its policy. These forecasts need not be those , or not exclusively those, which are generated by the Bank itself; they could, for example, be the private sector consensus forecast or a stated weighted average of Bank and non-Bank forecasts. This point is clearly anticipated in Hall and Mankiw (1994); using a non-Bank forecast has the attraction that it removes any temptation for the Bank to tamper with its forecasts as a substitute for persuasive explanation of its actions. Unfortunately, a problem with the Consensus forecast as presently constructed is that it is always a little out-of-date, in a context where timeliness is important.

3 The European Central Bank

We use the "perfect model" of Svensson as a benchmark for our analysis. Our simple extension of his original model to include two countries and two groups of goods/services allows us to highlight some potential issues for monetary policy in Europe. The first of these concerns the divergence of national rates of inflation from the European one.

3.1 How Common will the common rate of inflation be?

It is apparent that, whatever "European" rate of inflation the ECB achieves, inflation rates in individual countries will differ from it, and from each other. There are two potential sources for such potential differences. First, tastes and expenditure patterns vary between countries so that, even if all the sectoral inflation rates were the same, the national average inflation rates would not be. Second, we can expect to find that intersectoral inflation differentials differ between the countries, so that even in the stylized case where tradable goods prices and inflation rates are equalized and expenditure patterns are the same, national average inflation rates will not be the identical.

These potential national inflation differentials have some policy implications. First, the ECB and the public need to be aware that such differentials do not indicate that the policy of Europe-wide inflation targeting is a failure, but within some limits, are to be expected. To be more concrete, within a monetary union of disparate economies, it is only to be expected that equilibrium real exchange rates should change. The Harrod-Balassa-Samuelson theorem, for example, predicts that real exchange rates will tend to appreciate in the course of development; in a floating rate regime this might be accomplished by an appreciation, in the first instance, of the nominal exchange rate. In a monetary union, the same thing will be achieved by a rise in relative prices, which will appear like "excess inflation". Second, given that there is one risk-free interest rate in the Euro-Area, the fact that national inflation rates differ implies that real interest rates will differ between nations in the opposite direction: this is an element of the so-called "Walters critique" (Walters 1986). For a given financial structure, this implies a distortion in the monetary policy transmission process, since the countries with the lowest inflation have the highest real interest rates and vice-versa - although this may not be significant compared to the differences in financial structure of the member countries of the Euro-area (see BIS, 1995, for a collection of papers bearing on this issue).

To examine these issues empirically we use information on disaggregated consumer price indices for most (10) European countries obtained from Eurostat. Our data set comprises eight categories of goods and services, as shown in Table 1. The data are monthly and cover 1975:1-1996:10 for most countries. We have collected the weights used by the national statistical offices of a number of countries to construct the aggregate consumer price indices. Shown in Table 2, these are based on expenditure patterns and are derived

Table 1: Consumer Price Indices

2002 Food Excluding Drinks and Meals
2003 Drinks (Home Consumption) and Tobacco
2004 Clothing, Footwear including repairs
2005 Rent, Fuel, Power
2006 Household Goods and Services
2007 Transport, Communications
2008 Recreation, Education etc
2009 Other goods and Services including drinks and meals

Source: Eurostat, Cronos

from surveys and usually are updated on an annual basis.

3.1.1 Differences in tastes and expenditures

One way of estimating the potential effect of differences in expenditure weighting is simply to ask the question "what aggregate inflation rate would prevail in each country had the European average expenditure weights been used instead of that country's own weights?". That is, keeping the sectoral inflation rates at their historical values, we simply substitute European for national weights and recalculate the index. The EU weights are averaged across the countries and weighted by the share of each country's private national consumption to total European consumption. They are shown in the last column of Table 3. The table also reports the resulting cumulative differentials of country i's inflation calculated with national weights against (i.e.minus) the inflation rate calculated with European weights – so a positive sign shows that country i's inflation performance would have been better off had European weights been used for calculation of the CPI. The cumulative differentials are calculated relative to the first available observations - January 1975, for example. The monthly differential shows the average monthly difference between the two indices over the same period. This analysis reveals that the differences due to differences in expenditure patterns are small for most cases –Greece, Denmark, the Netherlands and the UK seem to stand out as exceptions. Take the UK as an example. The cumulative differential over the 20 years of the sample is 3.15 implying that the UK would, by construction, display lower prices increases if the EU weights were used to aggregate the CPI. (This result seems to be due predominantly to the UK's "drink problem": i.e. expenditure on drink in the UK has a relatively high weight and the drink sector's rate of inflation is relatively fast). It is not particularly easy to see why wage negotiations should become linked to European as opposed to

Table 2: Weights of main groups in CPI

	BE	DE	FR	GE	GR	IT	LU	NE	SP	UK
2002	20.4	14.3	17.8	15.3	20.5	19.7	14.6	14.9	26.2	22.8
2003	3.7	5.9	4.2	5.0	3.5	3.0	4.5	3.1	3.2	17.4
2004	8.7	5.3	6.5	8.3	11.1	11.7	11.7	7.2	11.4	6.1
2005	15.6	27.6	11.3	20.0	13.5	9.9	13.3	26.1	10.2	12.9
2006	9.1	6.0	8.2	7.8	8.3	9.9	12.0	8.0	6.6	9.9
2007	15.8	17.8	19.3	19.2	15.4	14.4	17.8	14.4	16.5	15.7
2008	12.4	11.6	8.2	11.3	8.1	9.1	14.1	10.7	7.2	3.2
2009	13.9	11.1	23.9	12.8	19.2	22.0	11.7	15.6	18.3	11.6
Health	0.8	0.2	9.5	1.1	5.7	1.5		0.6	3.1	3.1

Notes: 1. Health is included in 2009 with the exception of Denmark where it is included in 2208. 2. Sample periods are BE(75:1-96:10), DE(75:1-96:10), FR(75:1-96:10), GE(76:1-96:3), GR(75:1-96:4), IT(75:1-95:12), LU(75:1-96:10), NE(75:1-96:10), SP(77:1-96:10), UK(75:1-96:10). 3. The weights were obtained directly from national finance ministries/statistical offices.

national inflation rates, while substantial differences between them prevail: but if they did, then UK workers' excessive taste for drink and tobacco would be impoverishing.[1]

3.1.2 Sectoral inflation differences

The above model can be changed slightly to differentiate between a home-produced non-tradable good (good 1)and a tradable good (good 2) the price of which is determined by the "Law of One price" in the world market , as follows:

$$\pi^h_{1,t+1} = \pi^h_{1,t} + q^h + \alpha_1 y^h_t + \varepsilon_{1,t+1}$$
$$\pi^h_{2,t+1} = \alpha_3(\dot{e}^h_{t+1} + \pi_{2,t+1}) + \varepsilon_{2,t+1}$$

where e_t is the nominal exchange rate defined so that an increase implies a depreciation of the Euro, $\pi_{2,t}$ is the inflation rate of the traded good and is common across the two countries and q^h, q^f are drift parameters reflecting productivity growth. Similarly, we have comparable equations for the other country

[1]Of course it is not so much that that British workers' taste for drink and tobacco is excessive as their propensity to buy goods bearing excessively high rates of excise duty!

Table 3: Inflation differentials resulting from shift to EU average CPI weights

	Relative to EU average		
	cumm diff	montly diff	Weights
BE	-1.91	-0.007	3.2
DE	3.84	0.014	1.9
FR	0.64	0.002	18.6
GE	-0.12	0.000	28.8
GR	5.00	0.019	1.6
IT	0.50	0.002	17.0
LU	-1.60	-0.006	0.2
NE	4.32	0.018	4.6
SP	-1.30	-0.005	8.0
UK	3.15	0.012	16.0

Notes: (a) cumulative difference (cumm diff) shows the cumulative, over the sample period, divergence of inflation of country i had EU weights been used to aggregate the Consumer price index , (b) monthly difference (monthly diff) shows the average monthly change, (c) The weights for 1995 are derived from private final national consumption (Eurostat) at constant 1990 prices in ECUs.

$$\pi^f_{1,t+1} = \pi^f_{1,t} + q^f + \alpha_1 y^f_t + \varepsilon_{1,t+1}$$
$$\pi^f_{2,t+1} = \alpha_3(\dot{e}^f_{t+1} + \pi_{2,t+1}) + \varepsilon_{2,t+1}$$

For convenience we may call $\pi^T_t = \dot{e}_t + \pi_{2,t}$. One can also let the $\pi_{2,t}$ be determined exogenously, say by a first-order autoregressive process. If we repeat the same exercise we obtain an expression for EU-wide inflation rate as follows:

$$\pi^{eu}_{t+2} = \delta_1 \pi^h_{1,t} + \delta_2 \pi^f_{1,t} + \delta_3 \pi^T_t + \delta_4 \pi^T_{t+1} + \delta_4 \pi^T_{t+2} + \delta_5 y^h_t + \delta_6 y^f_t - + \delta_7 i^{eu}_t + errors \quad (8)$$

where $\delta_1 ... \delta_7$ are defined in the Appendix. If we further assume that the exchange rate is also given by a first order autoregressive process and set $\pi^{eu}_{t+2} = \pi^*$ to solve for i^{eu}_t we can re-write the reaction function of the authorities in terms of the interest rate or a composite interest rate-exchange rate indicator which we label MCI[2].

$$MCI_t = i^{eu}_t - \frac{\theta_2}{\theta_1} \dot{e}_t = b_1 \pi^h_{1,t} + b_2 \pi^f_{1,t} - b_3 \pi^* + b_3 \pi_{2,t} - b_4 \pi^* + b_5 y^h_t + b_6 y^f_t + errors \quad (9)$$

where $\theta_1 = a_3 + a_4(\rho_1 + \rho_1^2)$ and $\theta_2 = a_3 + a_4(\rho_2 + \rho_2^2)$. Hence in this model with a great deal of simplification the MCI is given an economic interpretation. This is exactly what the Bank of Canada is claiming. If any of the right

[2] We adopt this label from the practice of the Bank of Canada and the International Monetary Fund, of producing information on a "Monetary Conditions Index" (MCI), a combination of the short-term interest rate and the exchange rate. The Bank of Canada have been using the MCI as their main operational target for some years now and claim that it performs a better role than just the interest rate (see Freedman, 1994). The IMF regularly publish the MCI for the major industrialised countries in the World Economic Outlook. The increased volatility of exchange rates in the last 20 years motivated the Bank of Canada to look into this alternative index as an improved operational target. Freeman(1994) argues that the use of the MCI is important for the Bank of Canada's anti-inflation policy since "*If the central bank focused only on interest rate changes, it might tighten excessively in the case where most of the initial reaction to the change in the instrument occurred through an appreciation of the exchange rate, since it was not taking sufficient account of the downward pressure on aggregate demand that was taking place through the currency appreciation.*" (p.467).

hand side variables changes, relative to the target, given information at the end of time t, the monetary authorities will move the instrument taking into account the movements in the exchange rate. We refer to data on an analogous measure, in which the exchange rate augments the money supply in some empirical work reported later in this paper.

>From the above distinction it becomes clear that the inflation processes in the two countries differ to the extent to which the inflation in the non-traded goods sectors differs. It is commonplace to argue, as in the so-called "Scandinavian model" extension of the Harrod-Balassa-Samuelson theorem, that the scope for productivity growth is greater in the traded than in the non-traded goods sector, so that with a common rate of increase in money wages there will be a systematic tendency for the relative price of non-tradeables to rise.

To detect this effect by *a priori* identification of the expenditure categories of our price indices (Table 1) as either "non-traded" or "traded" is not easy. The disaggregation is relatively coarse and all categories contain a mix of traded and non-traded goods. On the assumption that these mixes remain relatively constant over time and are similar across countries, however, we might expect to find a systematic tendency for the rank correlations of sectoral inflation rates both across countries and through time to be significantly positive.

To test this we in fact calculate the correlation of ranks of inflation rates across countries and finally across countries and through time. For the former we average inflation rates over the available sample period, as shown in the table, and rank across the categories. We do that for all the countries of interest and then calculate the correlations as described below. These essentially reveal whether the rankings of the inflation rates across the eight different groups are similar across countries. Secondly, we calculate rank correlations for the inflation rates for these groups over time. This basically involves ranking the inflation rates across the groups at every point in time (monthly, annually or quarterly) and then estimating the correlation of these rankings.

Since we have several rankings for inflation rates (eight in our work) we use Kendall's coefficient of concordance (W) to determine the association among them. This measure is used as an extension of Spearman's (r_s) and Kendall's (T), which are used the express the association between two sets of ranks, for cases where more than two rankings are compared (see Kendall,

Table 4: Variation across countries/ across countries and time

Variation across countries							
2002	2003	2004	2005	2006	2007	2008	2009
2.6	5.0	3.9	6.9	2.5	4.9	2.7	7.5
10 countries,W=0.630, $\chi^2 = 43.96$							
Variation across countries							
2002	2003	2004	2005	2006	2007	2008	2009
2.0	5.6	3.5	7.3	2.6	5.16	2.3	7.3
6 countries*, W=0.789,$\chi^2 = 33.16$							

Notes: * Belgium, France, Germany, Netherlands, Spain, UK

1970, Siegel and Castellan, 1988, p.262, for more details)[3]. Under the null hypothesis the rankings are independent . When more than 7 groups are to be ranked the quantity $\chi^2 = k(N-1)W$ is approximately distributed as chi squared with N-1 degrees of freedom. The results are shown in Table 4. When the data is averaged and the rankings across the 8 groups are compared across countries $W = 0.63$ and is strongly significant. The relevant question to ask here is whether the inflation ranks are similar across the countries (Do prices for rent, fuel and power rise faster than the other caterories in all the countries?). When we restrict the sample to only six countries – Belgium, France, Germany, Netherlands, Spain, UK – the rank correlation rises to 0.79. The average rankings reported in the tables under each group (2002, ..., 2009) imply that the lowest inflation rates across these countries is for the 2006 group which is household goods and services, 2002 which is food excluding drinks and 2008 which includes recreation and education. This seems to be a robust finding. On the other hand rent, fuel and power, 2005, and the category "other goods and services" 2009 seem to experience higher inflation rates. These rankings according to our hypothesis provide an indication of the "tradable goods intensity" of the various expenditure categories.

Finally, we calculate the correlations for the rankings of inflation rates across time as shown in the first table —the results are reported in Table 5[4].

[3]For k rankings it is shown that the average value of Spearman's rank-order correlation coefficients between the $\binom{k}{2}$ possible pairs of rankings is related to W in the following way:
$ave(r_s) = \frac{kW-1}{k-1}$.

[4]What we are looking at here is whether the ranks for the inflation rates persist across time. One way to put it in words is to ask the question whether inflation for one category is consistently the highest throughout the sample period.

Table 5: Variation across countries and time

Variation across time and countries							
2002	2003	2004	2005	2006	2007	2008	2009
2.8	5.0	4.0	6.8	2.4	4.8	2.7	7.5
10 countries,W=0.605, $\chi^2 = 42.56$							

Table 6: Domestic Output Prices and CPI (1981-1995)

	WPI-I		WPI-II		CPI	
	Mean	Std	Mean	std	Mean	std
BE	2.13	5.68	2.11	5.62	3.98	1.86
FR	3.85	4.96	3.87	4.91	5.28	3.21
GE	1.81	2.74	0.87	1.72	2.68	1.49
GR	14.06	4.64	13.83	4.57	16.53	3.68
IT	5.30	3.64	5.32	3.32	7.98	4.04
LU	3.30	6.08	2.26	6.69	4.05	2.43
NE	0.96	5.76	-0.19	2.64	2.26	1.44
SP	5.65	4.98	5.54	5.03	7.85	3.03
UK	4.52	2.33	4.61	2.57	4.99	2.28

Notes: WPI-I: Domestic output price, total industry excluding construction, WPI-II domestic output price, manufacturing, source: Eurostat.

That is, after we have calculated the average ranking for each category across time, for each country, we calculate the rank correlations of these ranks. This is it is extremely similar to the results reported in Table 4. In the latter case, W=0.63, and in the former W=0.60.

The rank correlations support the hypothesis that the non-tradeables' relative prices tend to rise faster over time in all countries. However, this increase in relative prices is unlikely to be uniform across countries. Whilst, in a common currency area, the inflation rate (and price level) of tradable goods can be expected to be similar across countries, there are likely to be differences in the relative rate of increase of non-traded prices. One, structural, reason for this will have to do with differences in productivity growth; another, transitory in nature, has to do with underlying inflationary conditions. Where countries are suffering a growing lack of competitiveness due to a failure to control domestic inflationary pressures, the rise in the relative price of non-tradeables is likely to be accentuated. Micossi and Milessi-Ferretti (1996) report evidence from the Italian experience in favour of this suggestion. In effect, inflationary pressure, contained by competition and the fixed exchange rate regime in the tradeable goods sector, exhibits itself in

Table 7: Estimated sectoral inflation differentials

	75%-25%	90%-10%	Pn-Pt
BE	2.9	5.8	3.7
DE	2.7	4.7	
FR	2.3	4.3	2.8
GE	2.1	4.2	3.6
GR	6.3	9.9	5.4
IT	2.6	5.1	5.3
LU	2.6	6.8	3.5
NE	3.5	4.9	4.9
SP	4.1	6.7	4.6
UK	3.8	9.2	0.7

Notes: Pn-Pt computed by assuming proportion of traded goods is 0.5 from WPI-CPI data

the non-tradeables sector. The structural difference in productivity growth, however may be a persistent phenomenon. In order to adduce some broad orders of magnitude for this effect, using past data, we need information on two parameters – the proportion of consumer expenditure going on tradeables and the long term sectoral inflation differential. Neither of these can be measured with great accuracy. The work by Melliss (1993) on tradeable and non-tradeable prices in the UK was indicative of a share of expenditure on tradeables of between 40 and 67 per cent. The sectoral inflation differentials may be inferred from measures of the dispersion of inflation across the categories: the differences between the highest and lowest rate of inflation is one possibility. The interquartile range is another. More information is provided by wholesale price data; these should correspond almost entirely to traded goods. Table 6 in fact shows that the WPI inflation has been distinctly lower in all the countries in our study than CPI inflation. On the assumption that the proportion of tradable goods expenditure is about 50 per cent and that the WPI inflation is an accurate measure of tradeables price inflation, we can derive a third measure of the sector inflation differential which is shown, along with the dispersion-based measures, in Table 7. The significance of these figures lies basically in their cross-country differences. It is these which determine the extent to which national inflation rates can diverge from each other on a persistent basis. Taking 50 per cent, again, as an indicative figure of the tradeables expenditure proportion, the data in Table 7 could suggest for example, that the UK CPI inflation might exceed German inflation by between 0.8 per cent (0.5*(3.8-2.1)) and 2.5 per cent (0.5*(9.2-4.2)). Whilst the range is admittedly large and, at that, an underestimate of the uncertainty attaching to the figures, the substantial point is that a common currency for Europe and a common inflation policy do not imply identical inflation rates. The differences could be substantial, possibly more so than they are currently.

4 What inflation target for the ECB?

In choosing an explicit inflation target, the ECB will have to address the following issues. The first is which price index will be the one relevant for policy making. The statutes of the ECB, whilst specifying 'price stability' as the Bank's objective, are silent on this issue. The usual assumption, underscored in this case by the EMI's description of it as the ECB's "main measure of prices" (EMI 1997) - as well as by practice elsewhere in the world- is that inflation targeting will be directed at the CPI. The standard rationale for this is (see Hall and Mankiw, 1994) that the purpose of the strategy is basically to assist households in making efficient decisions. We do not wish to leave this choice entirely unchallenged, however: we briefly discuss below the alternative merits of the WPI as the main index at which stabilization efforts might be directed.

The second issue relates to the more general question of how best to measure inflation in the chosen index. Two problems have been identified in measuring inflation (see Cecchetti, 1996, for a general discussion). The first stems from *noise* originating from transitory changes in prices which in practise should not affect the actions of the policy makers. These include changes in the price of energy products, exchange rate movements and seasonal variations in prices and indirect taxes. A clear identification of these sources of variation is important for setting bands for inflation targets, the width of which should be set proportional to these variations. Alternatively, the announced targets should exclude categories of goods and services which generate this noise or some smoothed inflation rate like 'core' should be used for policy purposes. The second difficulty with measuring inflation comes from *biases* in weighting and sampling schemes as well as quality adjustments in the construction of consumer price indices. These biases are related to the methodology used to form aggregate price indices (weighting bias). In addition there are measurement biases (resulting from quality changes, for example). In this paper we are mostly concerned with the first problem, that of eliminating the noise originating from transitory shocks and producing a smoothed price index that can be used effectively as an indicator by the monetary authorities in deciding the policy stance.

4.1 Which Index?

The case for targeting a WPI index is primarily based on the assumption that the WPI refers almost exclusively to traded goods prices where the "law of one price" could be expected to hold. Thus for these goods, identical price levels should be expected to hold in the different countries (subject only to transport costs and segmented market discrimination). McKinnon(1996), for example, suggests that this would be the most appropriate target for a "G-3" exercise in which nominal exchange rate stability was sought, together with stable inflation. He argues that an attempt to stabilize CPI prices in such a context would be incompatible with maintaining stable nominal exchange rates (these being determined, essentially, by PPP in traded goods prices) because of differences in national inflation differentials between traded and non-traded goods prices. In our context, the stability of nominal exchange rates is ensured because monetary union has instituted a single currency: but the point could still be made that the presence of divergent national CPI inflation rates may undermine perceptions that the ECB is successfully stabilizing inflation. However the fact is that, although WPI inflation is lower and less divergent between countries than CPI inflation, it is notably more volatile (see Table 6). The chances of monetary policy responding to temporary shocks (or being perceived as failing) are enhanced in this case. As discussed below, it seems desirable that monetary policy should aim at stabilizing low frequency movements in prices. These appear easier to identify in CPI inflation processes.

4.2 Estimating core inflation

The term "core" inflation is often used informally in discussions of the inflation process; it has less frequently been the subject of a rigorous analysis and description. The most commonly used method of eliminating noise from inflation data has been the estimation of low-frequency trends of price indices or the exclusion of noisy categories of goods and services (food, fuel, indirect taxes etc). Such measures have often been defined as "core" inflation. In a more formal analysis Eckstein(1981) defined total actual inflation as the sum of a "core" rate, a demand rate and a shock term. Specifically, total inflation π is given by

$$\pi = \pi_c + \pi_d + \pi_s \tag{10}$$

and the core is defined as"*...that rate that would occur on the economy's long-term growth path, provided the path were free of shocks, and the state of demand were neutral in the sense that markets were in long-run equilibrium.*

The core rate reflects those price increases made necessary by increases in the trend costs of the inputs to production". Such a definition of the core inflation rate requires a formal structural model of the economy and it may therefore be less practical for policy evaluation and forecasting. Notice that such a definition of core inflation resembles that suggested by Quah and Vahey (1995) as that component of measured inflation that has no medium-to long-run impact on real output. This notion is basically consistent with a long-run vertical Phillips curve model of output and prices. Quah and Vahey (1995) used a VAR model and the identification technique of Blanchard and Quah (1989) to estimate core inflation. In contrast, Buiter and Miller (1981) and Bryan and Cecchetti (1994) define core inflation in terms of money growth. The latter interpretation is motivated by Ball and Mankiw's(1992) model of price setting. In Bryan and Cecchetti(1994) there are a large number of firms which in equilibrium choose to change their price by $\dot{m}$, the rate of monetary growth. Under these circumstances

$$\pi_c = \dot{m}$$

where it is assumed that money growth is exogenously determined and velocity is constant. Each firm faces a shock ε_i. In the case of instantaneous adjustment the price set by each firm will be

$$\pi_i = \dot{m} + \varepsilon_i$$

but in the presence of costs only some firms adjust. When the distribution of the shocks is symmetric, core inflation will be equal to observed inflation. But when the distribution is skewed these two measures will diverge. In these circumstances it is argued that limited-influence estimators of inflation, such as the median, will be more appropriate than the mean. This is due to the fact that the (cross-product, good or category) distribution of price changes is often leptokurtic which implies that the sample mean may not be the most efficient estimator of the cross-sectional distribution of inflation. For example, for the US the average sample kurtosis of monthly changes across the 36 components of the CPI exceeds nine (see Cecchetti, 1996, for example). For our case we have found smaller average (cross-sectional) kurtosis, which is mainly due to the fact that our data is aggregated over several product categories (in some cases it is around 5 or so).

A third measure of core inflation, suggested by Bryan and Cecchetti (1993), is identified by examining the co-movements of several price indices and assuming that the co-movements in these series arise from movements in the core inflation rate, π. In addition, each price movement is partly explained by idiosyncratic changes, which by definition are unrelated to changes in the core inflation rate. This amounts to specifying an unobserved single index model for consumer price indices. In this setup the estimated weights of the sub-indices are based on the strength of the core inflation signal relative to the idiosyncratic noise. Specifically,

$$\pi_t = \dot{m}_t + \dot{x}_t$$

$$\phi(L)\,\dot{m}_t = \delta + \eta_t$$

$$D(L)\,\dot{x}_t = \beta + \varepsilon_t$$

and the observed inflation rate, π_t, is the sum of common inflation $\dot{m}_t$ and relative price changes $\dot{x}_t$. We estimated this using the Kalman filter for a number of countries using the time series for the eight price series described before. Preliminary testing shows that the data are difference stationary and are not co-integrated. Consequently, the system is formulated in terms of first differences. Similar specification is used by Stock and Watson (1991) and Bryan and Cecchetti (1993). More details are included in the Appendix.

Table 8 shows the means and standard deviations for the three alternative measures of core inflation identified in the preceding discussion. CPIef is the CPI excluding food. This turns out to have a higher mean and for many countries more variability than the CPI itself. Cecchetti(1996) also concludes that this indicator, which is often used in discussions, does not have desirable properties. Med 1 and 2 are weighted-median inflation rates. The weights used are those shown in Table 2 and can be thought of as proxies for the number of prices in each category. Med-1 and Med-2 are the median of the cross sectional price changes over 12 and over 1 month. Clearly the latter scores better in terms of lower mean and standard deviation compared with CPI. The core is the common trend of the eight categories as identified by the unobserved component model. This measure seems to have nice characteristics. Figures 1 and 2 plot these different measures of core inflation rate for Germany and Italy.

4.3 Core Inflation and Money Growth and exchange rates

Earlier arguments suggested that a measure of core inflation should be more correlated with money growth than actual inflation. To check this we estimate the following simple augmented autoregression

Table 8: Means and standard deviations of percentage (over 12 months) changes

	CPI	CPIef	Med-1	Med-2	Core
BE	4.27	4.31	3.94	3.87	4.03
DE	5.67	5.73	5.68	5.04	5.46
FR	5.94	6.33	6.43	6.16	5.99
GE	2.97	3.14	3.01	2.91	2.89
GR	15.6	15.6	15.7	14.4	15.8
IT	9.66	10.00	9.73	8.77	9.54
LU	4.23	4.39	4.33	3.63	4.21
NE	3.35	3.40	3.35	2.10	2.81
SP	8.73	9.19	9.05	8.42	8.79
UK	7.17	7.28	6.84	6.58	6.62
	CPI	CPIef	Med-1	Med-2	Core
BE	2.49	2.23	2.36	2.04	1.91
DE	3.57	3.52	3.47	3.12	3.55
FR	3.85	3.78	3.96	3.46	3.51
GE	1.62	1.66	1.73	1.67	1.51
GR	4.11	4.91	4.69	5.14	4.08
IT	5.09	5.39	5.10	4.60	5.06
LU	2.81	2.95	2.71	2.19	2.38
NE	2.29	2.35	2.48	1.85	1.95
SP	4.36	4.89	5.07	4.11	4.31
UK	4.63	4.39	4.58	3.98	4.41

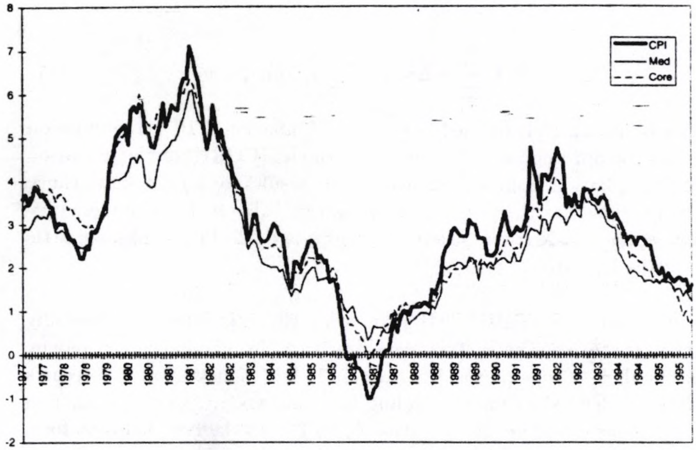

Figure 1: Germany-CPI, Med and core

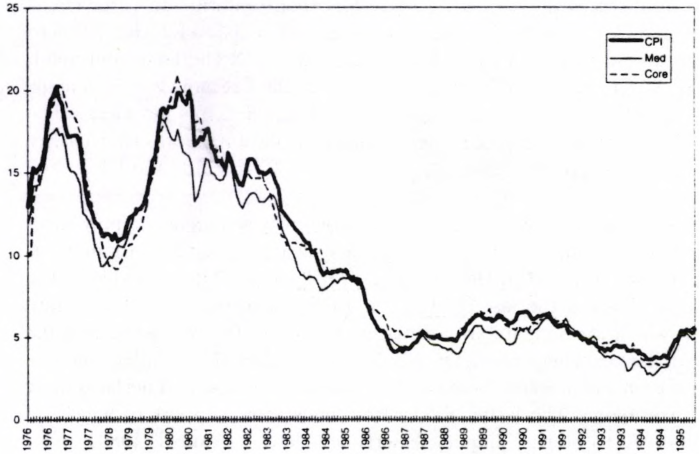

Figure 2: Italy - CPI, Med and core

$$\Delta p_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta p_{t-i} + \sum_{i=1}^{m} \gamma_i \Delta m_{t-i} + u_t \quad (11)$$

where Δp_t is alternatively defined as actual CPI inflation (CPI), core inflation as measured by our unobserved components model (CORE) or the deviation (dev) of CPI inflation from core inflation. The results for a joint significance test of γ_i expressed as the p-value, are shown in Table 9. For the monetary growth rate, data on M1 were used, with lags set to 12. The results are little affected if the lags are set to 6 or 18.

As Bryan and Cecchetti(1994) point out, the literature has generally found that these tests show that causality runs from inflation to money growth. In their study for the US they find that money growth forecasts core inflation (defined as food excluding food and energy, weighted median and trimmed mean) while the deviation of CPI from the core helps to forecast money growth; they take this as a sign of the monetary accommodation of aggregate supply shocks (as measured by "dev"). This, according to the authors, helps to explain the finding of the literature, that inflation causes money.

The results presented in Table 9 are less than uniform. In three countries, Belgium, Greece and Portugal money growth helps to forecast the core inflation rate but not the CPI. In Germany, Italy, the Netherlands and Spain money growth forecasts CPI, not core. Finally in the UK money growth helps to forecast both CPI and core inflation. So the evidence is not clear. The results show little evidence of monetary accommodation, shown as causality of dev for money growth. The only two cases are Greece and the UK.

It is arguable, however, that for open economies the money supply measure should be augmented by a term in the exchange rate. The argument is similar to that involved in the use of the MCI index. This in Table 9, the variable m^c used in the last columns, is a composite money-exchange rate index in which the weights are arbitrarily chosen as 0.7 on money and 0.3 on the (dollar) exchange rate. The results suggest that this variable contains useful information in some instances – for Greece, Portugal and perhaps most notably Germany. The latter observation lends some support to what has been observed to be the "implicit emergency clause" (Vaubel, 1980) under which German monetary policy has switched from monetary to exchange rate targeting when the exchange rate has appreciated strongly.

Table 9: Granger causality forecasting ability

		m to π	π to m	m^c to π	π to m^c
BE	CPI	0.320	0.753	0.295	0.691
	CORE	0.097*	0.841	0.058*	0.962
	dev	0.024**	0.928	0.022**	0.702
FR	CPI	0.239	0.058*	0.373	0.080*
	CORE	0.881	0.081*	0.855	0.004**
	dev	0.201	0.154	0.141	0.102
GE	CPI	0.014**	0.437	0.008**	0.230
	CORE	0.393	0.707	0.607	0.485
	dev	0.123	0.580	0.021**	0.144
GR	CPI	0.147	0.434	0.032**	0.838
	CORE	0.046**	0.087*	0.009**	0.244
	dev	0.190	0.029**	0.041**	0.677
IT	CPI	0.004**	0.167	0.003**	0.012*
	CORE	0.314	0.766	0.001**	0.155
	dev	0.593	0.292	0.275	0.302
NE	CPI	0.085*	0.186	0.108	0.497
	CORE	0.839	0.717	0.482	0.096*
	dev	0.529	0.156	0.419	0.204
PO	CPI	0.395	0.972	0.145	0.462
	CORE	0.046**	0.711	0.007**	0.050*
	dev	0.056*	0.676	0.003**	0.066*
SP	CPI	0.071*	0.211	0.891	0.233
	CORE	0.437	0.768	0.985	0.769
	dev	0.096*	0.129	0.999	0.636
UK	CPI	0.029**	0.136	0.121	0.206
	CORE	0.070*	0.015**	0.109	0.090*
	dev	0.107	0.000**	0.329	0.027

*Notes: *, ** significant at 90 and 95 per cent respectively.*

Whilst these results show that for the purposes of ex post analysis the index contains additional information it is unlikely that a large economy, such as the Euro-Area is likely to be, will find it useful to monitor such an index to the same extent as the Bank of Canada does. To the extent that trade with Japan, the Far East and the United States is conducted in a currency other than the Euro such an index may prove useful in smoothing interest rate movements in the face of currency fluctuations.[5]

Preliminary investigation therefore shows that these measures of core inflation are, for some countries at least, more correlated with money growth than CPI growth itself, particularly when money growth is adjusted for exchange rate change.

4.4 Forecasting CPI Inflation

The final piece of evidence we present is the ability of the various "core" inflation measures to forecast CPI inflation at horizons of 12, 24 and 36 months, better than inflation itself. Such a result should not be unexpected since forecasts are inherently "smooth" and our core inflation measures are constructed as smoothed estimates of the inflation process. The estimation follows Bryan and Cecchetti's (1994) methodology. The regressions are of the following form:

$$\frac{1}{k}\left[\ln(CPI_{t+k}) - \ln(CPI_t)\right] = \alpha + \beta(\ln p_t - \ln p_{t-12}) + \varepsilon_t$$

where p is alternatively, CPI, median or "common component" inflation and $k = 12, 24, 36$ months. We estimate this for a period which excludes 90 months at the end of the sample. We then produce dynamic forecasts and report the Root-Mean-Square forecast error in Table 10. The stars indicate cases where there is an improvement in the RMSE for forecasting CPI growth when either the "common component" core or median (Med-2) inflation rates are used as explanatory variables. Although this is a very simple and naive exercise it helps to illustrate a number of points. In a few cases there seems to be a benefit in using these indicators for forecasting inflation. This is important for longer horizons, that is for k=24 and 36. It must be the case that a more detailed examination of these indicators for each country will be

[5]Whilst the exchange rate may not be significant for inflation control, the Euro-exchange rate against the US dollar and the Yen may be highly significant in another respect - that of international trade policy. The preservation of the open global trading regime may depend critically upon the stabilisation of the *real* Euro rate of exchange against these currencies.

Table 10: Comparison of Forecasts of CPI over 90 months - Root Mean Square Error

k	12			24			36		
	CPI	Core	Med	CPI	Core	Med	CPI	Core	Med
BE	0.068	0.064*	0.064*	0.067	0.068	0.066*	0.062	0.082	0.069
DE	0.080	0.066*	0.115	0.079	0.064*	0.129	0.079	0.061*	0.123
FR	0.047	0.060	0.070	0.047	0.058	0.067	0.056	0.058	0.065
GE	0.068	0.075	0.068	0.061	0.072	0.059*	0.063	0.071	0.065
GR	0.272	0.300	0.308	0.284	0.291	0.293	0.260	0.264	0.267
IT	0.068	0.078	0.089	0.071	0.077	0.085	0.108	0.110	0.119
LU	0.075	0.072*	0.073*	0.073	0.074	0.075	0.070	0.075	0.082
NE	0.067	0.061*	0.074	0.061	0.055*	0.065	0.058	0.056*	0.062
SP	0.081	0.086	0.091	0.105	0.103*	0.125	0.099	0.097*	0.122
UK	0.183	0.221	0.214	0.191	0.217	0.217	0.196	0.209	0.210

Notes: Dynamic forecasts for models estimated over sample excluding last 90 months which are used for forecasting. (*) shows an improvement in the RMSE (not a statistical test).

able to produce measures for core inflation which have this nice property, of being able to forecast inflation better than the CPI itself, and which are less volatile than CPI growth. The latter point is important since monetary policy adjustment should disregard noise and respond only to important changes in expected prices.

5 Conclusions

This paper has been primarily concerned with some "nuts and bolts" questions that would arise in the event that the European Central Bank should decide to adopt "direct inflation targeting" and, below, we summarize some of the conclusions that emerge from this analysis. Before broaching these issues, however, we can offer some thoughts on the background to the EMI's decision to leave the field to the two alternatives of monetary and inflation targeting and on its exclusion of nominal income targeting.

The statutory independence of the European Central Bank and the assignment to it of price stability as its central objective reflect the arguments developed in the academic literature to the effect that objectives which are more even-handed as between output and prices and Central Banks which are less than fully independent bring with them an inflation bias in equilibrium. That bias can in effect be viewed as an insurance premium paid for the potential reduction in output variability, and the arrangements set up in the statutes of the ECB tend in the direction of suggesting that "Europe" is not willing to pay such a premium. In appraising the alternative strategies, however, it may be wise to accept that countries will likely wish to avail themselves of a degree of flexibility on occasion, and that if the ECB's policies do not reflect this to some extent, the response of member governments through other channels may prove a worse alternative.

This being so, one of the things that can be said about inflation targeting is that it may be insufficiently accommodating . Without any escape clauses or retargeting triggers and without any exclusions from the index, the strategy could be the means by which "excessively harsh" adjustments are forced onto the constituent economies of the Euro-area; whilst wide bands can help to accommodate the problem, the obvious difficulty is that "excessively wide" bands undermine the credibility of the policy. In inflation targeting practice elsewhere, exceptions are made for energy price or terms of trade shocks. It turns out that, formally speaking, nominal income/growth targets are equivalent to price level/inflation targets for demand shocks but differ for supply shocks, in that nominal income targets partially accommodate these, whilst inflation targets do not: yet, as just noted ,this is the type of shock in respect of which inflation targeting is most commonly qualified by an escape clause of some kind. In this sense the EMI perhaps drew too strong a contrast between nominal income and inflation targeting. But , what is often seen as a weakness of nominal income targeting - which is that information on nominal income outturns is not released any earlier than, but simultaneously with information on its "breakdown" into output and prices - remains a weakness: in general, it is not clear why the ECB would want to stick to a precommitted nominal income target in the light of outturns for prices and output that might strongly suggest a change in the target rate.

The practice of monetary targeting has been widely superceded in the world - except, notably, in Germany - by direct inflation targeting largely because it has been shown to contain significant weaknesses. Financial innovations have been widely blamed for instability in money demand functions and the example seems a sure bet for a structural change as big as EMU. There are two main countervailing arguments: first, that German monetary policy has not been perceived to suffer from the same problem; second, that the German example has acquired special significance for Europe - after all, the statutes of the ECB largely reproduce those of the Bundesbank (with, some would say, a hardening in a number of areas), so that it might seem strange to want at one and the same time to emulate the Bundesbank and yet not to adopt its strategy.

As it happens, it can be argued that Bundesbank policy in practice exemplifies a combinatorial strategy in which both an inflation target and a monetary target play a role. Thus, monetary target misses are far more common than not in Bundesbank history but these misses have not robbed the Bundesbank of its credibility because it has ensured low inflation. This seems like a plausible pointer to ECB strategy, except that as a new institution with no history and as an international institution answerable to a variety of constituencies (not, surely, to none?) it seems likely that any strategy it adopts will need to be more formal , more explicit and with less room for discretion. If so, the inflation target component of its strategy will be host to a number of detailed technical issues such as we have discussed above and now recapitulate below.

To support our discussion of these "nuts and bolts" issues we adapted a model suggested by Svensson to a two-country setting, where we think of the two countries as forming a currency union. An important point that can be made immediately with the model, though it is one that has been articulated by Svensson elsewhere, is that, in effect, under inflation targeting it is the Central Bank's reaction to inflation forecasts which form the essential basis for judgment of its reactions. Thus, if the ECB were in fact to adopt inflation targeting, it should also make very clear what its forecasts are; and in order to prevent tampering with the forecasts it might be argued that the forecasts against which it is to be judged should be generated from outside the Bank.

In adopting an inflation target, the ECB should also be clear that national inflation differentials will persist. We showed here that such deviations could in principle be "equilibrium" deviation, in the sense that warranted real exchange rate adjustments will have to take place in the form of relative price changes, that will appear as inflation differentials. It is possible that the extent of these could be quite large and that, without explanation, they could undermine perception of the ECB's effectiveness.

We argued also that it is desirable that inflation targeting should not lead to responses to idiosyncratic price movements. There are different ways of dealing with this. One is to set bands around the central target large enough to accommodate such idiosyncratic shifts. Another is to eliminate from the index potentially troublesome components. A third method is to write into the target commitment an escape clause which should allow the target to be reset in the event of (prespecified) shocks. The method that we discussed, and explored empirically, is to focus on a measure of "core inflation". It is arguable that it is such a notion of "underlying inflation" that should form the true target and that, empirically, this is a smoothed version of actual inflation. Commonly cited smoothing devices such as moving averages, have the disadvantage of losing timeliness, however. We explored alternative measures which do not suffer from this drawback. Substantial advantages were discovered in a measure of core inflation generated by applying a "common components" analysis.

"Direct" inflation targeting is not quite as simple as it sounds.

A Appendix

A.1 The two-country Model

Equation 2

$$\begin{aligned}
\pi^{eu}_{t+1} &= \kappa\pi^h_{t+1} + (1-\kappa)\pi^f_{t+1} \\
&= \kappa w_h \pi^h_{1,t} + \kappa(1-w_h)\pi^h_{2,t} + (1-\kappa)w_f\pi^f_{1,t} + (1-\kappa)(1-w_f)\pi^f_{2,t} \\
&\quad +\kappa\alpha_1 y^h_t + (1-\kappa)\alpha_1 y^f_t + \alpha_2 x_t \\
&\quad +\kappa w_h\varepsilon_{1,t+1} + \kappa(1-w_h)\varepsilon_{2,t+1} + (1-\kappa)w_f\varepsilon_{1,t+1} + (1-\kappa)(1-w_f)\varepsilon_{2,t+1}
\end{aligned}$$

which is simplified to

$$\pi^{eu}_{t+1} = \pi^{eu}_t + \alpha_1 y^{eu}_t + \alpha_2 x_t + \xi_{t+1}$$

Equation 3

$$\begin{aligned}
y^{eu}_{t+1} &= \kappa\left[\beta_1 y^h_t + \beta_2 y^f_t - \beta_3(i^{eu}_t - \pi^h_t) + \beta_4 x_t + \eta^h_{t+1}\right] \\
&\quad +(1-\kappa)\left[\beta_1 y^f_t + \beta_2 y^h_t - \beta_3(i^{eu}_t - \pi^f_t) + \beta_4 x_t + \eta^f_{t+1}\right]
\end{aligned}$$

$$\begin{aligned}
y^{eu}_{t+1} &= \beta_1 y^h_t + \beta_2 y^f_t + \kappa(\beta_1-\beta_2)y^h_t + \kappa(\beta_2-\beta_1)y^f_t \\
&\quad -\kappa\beta_3(i^{eu}_t - \pi^h_t) - (1-\kappa)\beta_3(i^{eu}_t - \pi^f_t) + \beta_4 x_t + \left[\kappa\eta^h_{t+1} + (1-\kappa)\eta^f_{t+1}\right]
\end{aligned}$$

$$\begin{aligned}
y^{eu}_{t+1} &= \beta_1 y^h_t + \beta_2 y^f_t + \kappa(\beta_1-\beta_2)(y^h_t - y^f_t) \\
&\quad -\kappa\beta_3(i^{eu}_t - \pi^h_t) - (1-\kappa)\beta_3(i^{eu}_t - \pi^f_t) + \beta_4 x_t + \eta^{eu}_{t+1}
\end{aligned}$$

where $\eta^{eu}_{t+1} = \kappa\eta^h_{t+1} + (1-\kappa)\eta^f_{t+1}$.

Equation 4

$$\begin{aligned}
\pi^{eu}_{t+2} &= \left[\pi^{eu}_t + \alpha_1 y^{eu}_t + \alpha_2 x_t + \xi_{t+1}\right] \\
&\quad +\alpha_1[\beta_1 y^h_t + \beta_2 y^f_t + \kappa(\beta_1-\beta_2)(y^h_t - y^f_t) - \kappa\beta_3(i^{eu}_t - \pi^h_t) - \\
&\quad (1-\kappa)\beta_3(i^{eu}_t - \pi^f_t) + \beta_4 x_t + \eta^{eu}_{t+1}] \\
&\quad +\alpha_2\left[\gamma x_t + \theta_{t+1}\right] + \xi_{t+1}
\end{aligned}$$

$$\begin{aligned}\pi^{eu}_{t+2} &= \pi^h_t + (1-\kappa)\pi^f_t + \kappa\alpha_1\left(\kappa y^h_t + (1-\kappa)y^f_t\right) + \alpha_2 x_t + \xi_{t+1} \\ &+\alpha_1[\beta_1 y^h_t + \beta_2 y^f_t + \kappa(\beta_1-\beta_2)(y^h_t - y^f_t) - \kappa\beta_3(i^{eu}_t - \pi^h_t) - \\ &(1-\kappa)\beta_3(i^{eu}_t - \pi^f_t) + \beta_4 x_t + \eta^{eu}_{t+1}] \\ &+\alpha_2\left[\gamma x_t + \theta_{t+1}\right] + \xi_{t+2}\end{aligned}$$

We collect the terms and simplify

$$\begin{aligned}\pi^{eu}_{t+2} &= a_1\pi^h_t + a_2\pi^f_t + a_3 y^h_t + a_4 y^f_t - a_5 i^{eu}_t + a_6 x_t \\ &+\left(\xi_{t+1} + \xi_{t+2} + \alpha_1\eta^{eu}_{t+1} + \alpha_2\theta_{t+1}\right)\end{aligned}$$

where

$$\begin{aligned}a_1 &= \kappa(1+\alpha_1\beta_3) \\ a_2 &= (1-\kappa)(1+\alpha_1\beta_3) \\ a_3 &= \alpha_1\kappa + \alpha_1\beta_1 + \alpha_1\beta_1\kappa - \alpha_1\beta_2\kappa \\ a_4 &= \alpha_1(1-\kappa) + \alpha_1\beta_2 - \alpha_1\beta_1\kappa - \alpha_1\beta_2\kappa \\ a_5 &= \alpha_1\beta_3 \\ a_6 &= \alpha_1\gamma + \alpha_1\beta_4\end{aligned}$$

Equation 7

$$\begin{aligned}i^{eu}_t &= \frac{1}{a_5}\left[-\pi^* + a_1\pi^h_t + a_2\pi^f_t + a_3 y^h_t + a_4 y^f_t + a_6 x_t\right] \\ &= b_1\pi^h_t + b_2\pi^f_t - b_3\pi^* + b_4 y^h_t + b_5 y^f_t + b_6 x_t\end{aligned}$$

Equation 8

Set the productivity drifts equal to zero for simplicity and solve as before to derive equation (8) where:

$$\begin{aligned}\delta_1 &= \kappa w_h + \kappa^2\alpha_1\beta_3 \\ \delta_2 &= (1-\kappa)w_f + (1-\kappa)\kappa w_f\alpha_1\beta_3 \\ \delta_3 &= \kappa(1-\kappa)w_h\alpha_1\beta_3 + (1-\kappa)^2 w_f\alpha_1\beta_3 \\ \delta_4 &= \kappa w_f + (1-\kappa)w_h \\ \delta_5 &= \kappa w_h\alpha_1 + \kappa w_h\alpha_1\beta_1 \\ \delta_6 &= (1-\kappa)w_f\alpha_1 + (1-\kappa)w_f\alpha_1\beta_1 \\ \delta_7 &= \kappa w_h\alpha_1\beta_3 + (1-\kappa)w_f\alpha_1\beta_3\end{aligned}$$

Equation 9
We assume that

$$\begin{aligned} \pi_{2,t+1} &= \rho_1 \pi_{2,t} + z_{t+1} \\ \dot{e}_{t+1} &= \rho_2 \, \dot{e}_t + r_{t+1} \end{aligned}$$

A.2 Dynamic Factor Index Model

In this section we present estimates of core inflation obtained from a dynamic factor model as proposed by Bryan and Cecchetti(1993). This is essentially the dynamic factor index model of Stock and Watson(1991), originally applied to analyze business cycles, and can be described by the following sets of equations:

$$\dot{\pi}_t = \dot{m}_t + \dot{x}_t \tag{12}$$

$$\phi(L) \, \dot{m}_t = \delta + \eta_t \tag{13}$$

$$D(L) \, \dot{x}_t = \varepsilon_t \tag{14}$$

Thus, the observed inflation rate, π_t, is the sum of common inflation m_t and relative price changes x_t. In addition, $\phi(L)$ and $D(L)$ are a vector and matrix lag polynomials of orders p and k respectively. The model is identified by assuming relative price changes are uncorrelated with core inflation. In addition, $D(L)$ is diagonal,

$$D_i = diag(d_{1i}, ...d_{ni})$$

with $d_j(L) = 1 - \sum_{i=1}^{k} d_{ji} L^i$ and where

$$E \begin{bmatrix} \eta_t \\ \varepsilon_t \end{bmatrix} \begin{bmatrix} \eta_t & \varepsilon_t' \end{bmatrix} = \Sigma = diag(\sigma_\eta^2, \sigma_{\varepsilon_1}^2, ..., \sigma_{\varepsilon_n}^2)$$

In the Stock and Watson(1991) formulation the transition and measurement equations are given by:

$$\begin{bmatrix} m_t^* \\ x_t^* \\ m_{t-1} \end{bmatrix} = \begin{bmatrix} \delta \\ 0_{(p+nk)\times 1} \end{bmatrix} + \begin{bmatrix} \phi^* & 0 & 0 \\ 0 & D^* & 0 \\ Z_m & 0 & 1 \end{bmatrix} \begin{bmatrix} m_{t-1}^* \\ x_{t-1}^* \\ m_{t-2} \end{bmatrix} + \begin{bmatrix} Z_m' & 0 \\ 0 & Z_u' \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \eta_t \\ \varepsilon_t \end{bmatrix} \tag{15}$$

$$\pi_t = \left[\begin{array}{ccc} Z_m & Z_u & 0_{(n+1)} \end{array} \right] \left[\begin{array}{c} m_t^* \\ x_t^* \\ m_{t-1} \end{array} \right] \qquad (16)$$

where

$$m_t^* = \left[\begin{array}{ccc} \dot{m}_t, & \dot{m}_{t-1}, & ..., \dot{m}_{t-p-1} \end{array} \right]'$$

$$x_t^* = \left[\begin{array}{ccc} \dot{x}_t', & \dot{x}_{t-1}', & ..., \dot{x}_{t-k-1}' \end{array} \right]'$$

$$\phi^* = \left[\begin{array}{cccc} \phi_1 & ... & \phi_{p-1} & \phi_p \\ & I_{p-1} & 0_{(p-1)\times 1} & \end{array} \right]$$

$$D^* = \left[\begin{array}{cccc} D_1 & ... & D_{k-1} & D_k \\ & I_{n(k-1)} & 0_{n(k-1)\times n} & \end{array} \right]$$

$$Z_m = \left[\begin{array}{cc} 1 & 0_{1\times(p-1)} \end{array} \right]$$

$$Z_u = \left[\begin{array}{cc} I_n & 0_{n\times n(k-1)} \end{array} \right]$$

The system can be re-written in a compact form and estimated by maximum likelihood using the Kalman filter. The core price index is computed as the minimum mean square linear estimate of the core index $\dot{m}_{t|t}$ produced by applying the Kalman filter to the estimated system and $\dot{m}_{t|t}$ is a linear combination of the current and past price sub-indices. The weights used by the Kalman filter to construct $\dot{m}_{t|t}$ from consumer price sub-indices can be calculated by computing the response of $\dot{m}_{t|t}$ to unit impulses in each of the observed price variables. More details about the estimation in Stock and Watson (1991).

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