Long Range Inflation Prospects
A Report for Barrie Hibbert

Paul Ormerod and Bridget Rosewell, Volterra Consulting

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Summary

- The purpose of this paper is to consider the prospects for inflation in the UK and the EU over the long term
- In particular, the focus is on estimating the more extreme possibilities, and specifically the rates with a 1 in 20 chance of happening at the upper and lower range of potential outcomes.
- We provide a central view at horizons of 1, 3, 5, 10 and 20 years, with 5/95 percentiles for each of these dates. In addition, we provide estimates of the volatility (standard deviation) of inflation
- There has undoubtedly been a period of general stability by historical standards over the past decade or so. This leads many people to imagine that this will continue automatically. It is well known, however, that humans find it very hard to imagine dramatic changes and the ending of apparently stable systems or periods of time
- For 2026, we obtain a much wider potential range of inflation for both the UK and the EU than many people might expect.
- The upside potential for inflation has generally been quite large. Although in principle prices could fall as fast as they rise, downward stickiness has been a more prevalent feature of economies than upward resistance. The distribution is therefore skewed and the arithmetic mean is considerably higher than the median.
- The median projection for the long run is therefore 2.2% for the UK, and 3.4% for the EU, while the arithmetic mean is 3.1% in the UK and 5.2 % in the EU.
- For 2026, the 5 percentile estimate is an inflation rate of -4.6% in the UK and -7.1% in the EU. The 95 percentile estimate is 15.0% in the Uk and 24.5%in the EU

1 Introduction

The purpose of this paper is to consider the prospects for inflation in the UK and the EU over the long term. In particular, the focus is on estimating the more extreme possibilities, and specifically the rates with a 1 in 20 chance of happening at the upper and lower range of potential outcomes.

The methodology inevitably differs from standard approaches used to address such questions using data from financial markets. This is for several reasons. For example, very large amounts of completely accurate data are available in considering financial variables such as interest rates or bond prices. In contrast, inflation data is estimated and may contain inaccuracies. More importantly, it is sampled at much lower frequencies, particularly over a longer historical period. Annual estimates are often the only ones which are available, so there are many fewer data points than are available in financial markets.

A further key consideration is that in analysing, say, option prices of equities , there is a set of analytical models which is common ground amongst researchers. The mathematics of the models may be very hard for the non-specialist to follow and their empirical implementation may be a decidedly non-trivial task, but there is a general consensus on how to approach problems in this area.

In contrast, with inflation, no such clear-cut agreement exists. Economists postulate at any point in time that there is a connection between the rate of inflation and the level of demand in the economy. The stronger is demand, for example, the higher the rate of inflation is likely to be. There is no consensus, however, as to the variable or variables which should be used empirically to express the level of demand. Unemployment is frequently used, and was indeed chosen for the seminal article on the so-called Phillips curve attempting to describe the relationship between inflation and the level of demand in pre-First World War Britain[1].

But even then, different researchers may estimate different functional forms for any particular empirical relationship. Much more importantly, such relationships are well known not to be time invariant. In other words, a reasonable relationship may be discovered to hold in a given economy over some particular period. However, at some (unknown) point in the future, it will break down.

More generally, in 1968 Milton Friedman published a very influential paper in the *American Economic Review* arguing that in the long-run there is no connection between inflation and the state of demand[2]. In so far as there is consensus on these matters amongst economists, this is it. However, the 'long run' is a theoretical concept, and economic theory offers no guidance as to how long the long run might be in practice.

So at any point in time there may very well be a well-defined connection between inflation and the state of demand. But at some point this will break down, and in any event in the long run there is no such connection.

[1] A.W. Phillips, "The relationship between unemployment and the rate of change of money wages in the UK 1861-1957, Economica, 1958

[2] M.Friedman, "The Role of Monetary Policy", *AER*, Vol. 58, No. 1, (March), pp. 1-17, 1968

The implication of the above is that purely statistical analysis is simply not sufficient to analyse the potential range of outcomes for inflation in the future. Our method is therefore based both on statistical analysis, historical context and our experience as forecasters and economists.

We attempt to formalise the analysis as much as possible and identify using statistical techniques several different inflation 'regimes' which have existed in the past. We establish that at different times, different regimes of inflation experience have been experienced and we consider the likelihood of these regimes, and transition between these regimes, in the future.

We provide a central view at horizons of 1, 3, 5, 10 and 20 years, with 5/95 percentiles for each of these dates. In addition, we provide estimates of the volatility (standard deviation) of inflation.

2 Data

Long range forecasts require long range data. In general, standard government data sources present little information before 1950. Fortunately, longer range data sets have been constructed by researchers, notably Angus Maddison at the Organisation for Economic Co-operation and Development. He has constructed comparable data on inflation and other core economic variables for all the major Western economies over the period 1870 to 1994[3]. We have added on more recently published information up to 2005, and estimates for 2006.

Our focus of interest is the UK and the EU. Clearly, while the UK's boundaries have not changed during this historical period, the EU has both been invented and changed its membership during this time.

Our definition of the EU prior to its existence takes data for the major countries of Italy, Germany and France and weights their individual inflation rates by the size of their economies to produce an overall EU estimate. Subsequent to its formation, we take information for the twelve countries of the EU, and then for the current 25[4].

Figure 1 sets out the estimates of inflation in the UK and the EU over the 1871-2006 period.

[3] A.Maddison, *Dynamic Forces in Capitalist Development*, Oxford University Press, 1991
[4] The source for this is the *Red Book* published regularly by HM Treasury

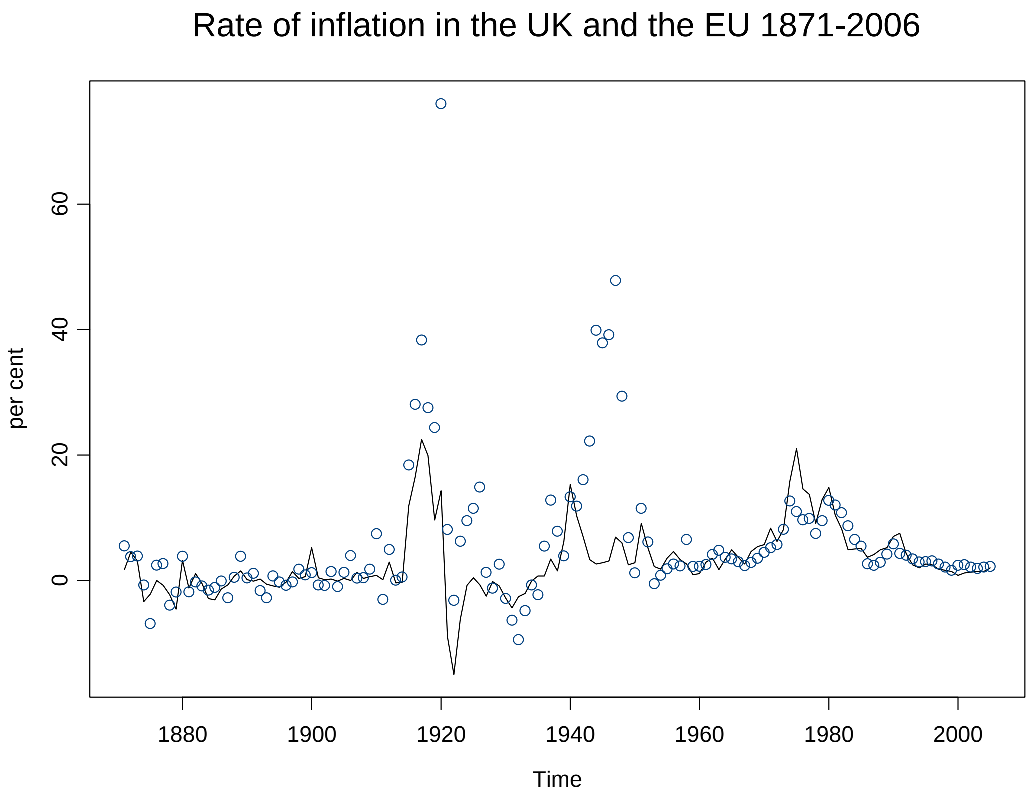

Figure 1 *Rate of inflation in the UK and the EU 1871-2006. UK is solid line, EU is dotted line. The German hyper-inflation of the early 1920s is excluded from the estimate of EU inflation*

Following the defeat in the First World War, there was intense internal conflict in Germany and by 1920 inflation was over 100 per cent a year. This process culminated in the notorious hyper-inflation of 1923, when prices rose by over a billion per cent. The hyper-inflation period is excluded from the EU data, which uses just France and Italy for the relevant years.

There are two features of the historical experience which are perhaps surprising, at least to most British readers. First, the average inflation experience since the Second World War is very similar in both the UK and the EU. The average annual rate since 1950 is 5.2 per cent in the UK and 4.7 per cent in the EU. The British perspective is usually distorted by thinking of Germany as representing the experience of the EU over this period. In fact, the other two major economies, France and Italy, have been as prone to outbreaks of inflation as the UK.

Second, over a longer perspective, the economies of Continental Europe are much more susceptible to periods of very high inflation than the UK has been. Such episodes are by no means frequent, but they do take place. An important aspect of judgment about the future is the probability which is attached to similar events taking place.

In order to consider the potential existence of different inflation regimes, we wish to consider different levels of demand in the respective economies. Our preferred measure for this is unemployment, which is capable of a long run of measures with reasonable consistency. We have used this for the UK. In Europe, however, unemployment data is not generally available on an annual basis before the Second World War. As the measure of demand here, we use the rate of growth of output (GDP). There is in general a close connection between the rate of growth of output and the rate of unemployment. If output falls, for example, in a recession, jobs are lost and unemployment rises.

Figure 2 below plots the relationship between inflation and unemployment in the UK.

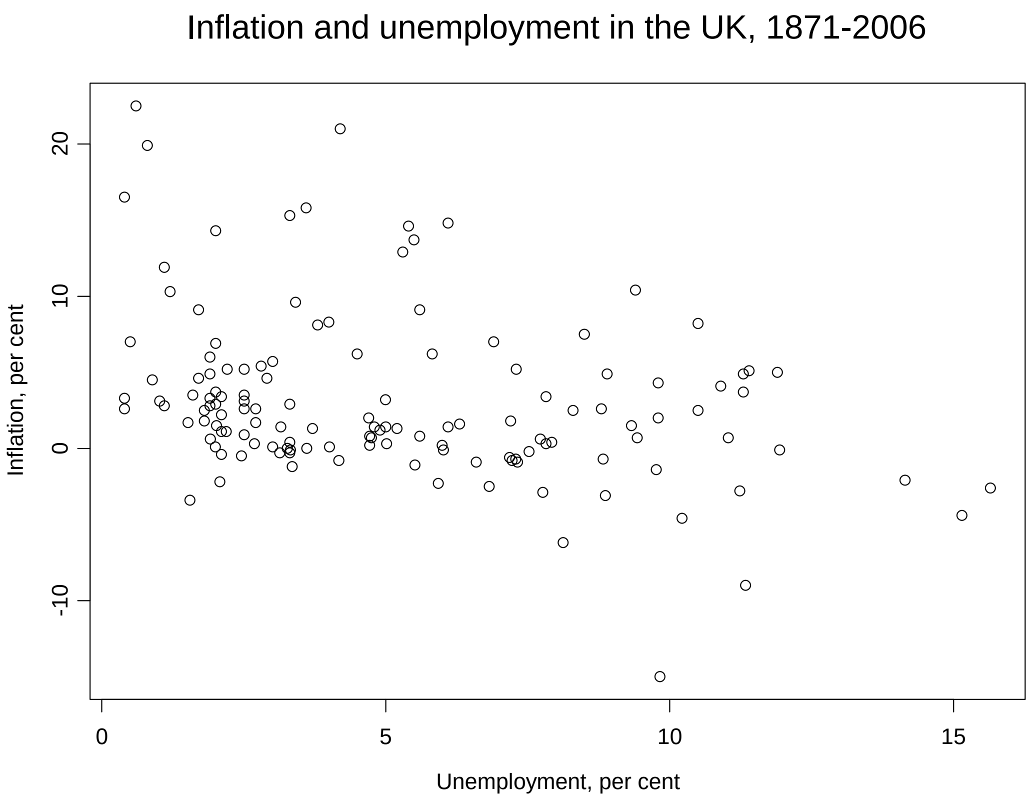

Figure 2 *Inflation and unemployment in the UK 1871-2006*

The chart confirms the general negative relationship between the level of demand and the rate of inflation. The lower the level of demand and so the higher the rate of unemployment, the lower the rate of inflation.

Equally, however, inspection of the chart shows clearly that very similar rates of unemployment have been associated with very different rates of inflation. It is for this reason that we try to identify different historical 'regimes' of the relationship.

3 Historical Regimes of Inflation

Methodology

We use the statistical technique of clustering to identify different historical experiences of inflation. Clustering is a standard technique which is used widely across a range of disciplines. It examines the attributes of each particular observation in a data set, and groups together those observations with similar attributes. In this case, each year has a rate of inflation associated with it, and for the UK a rate of unemployment and for the EU a rate of growth of output. These are the relevant attributes.

At one extreme, if the attributes were very similar across all observations, the data would be grouped into a single cluster. At the other, if each observation (year) had very different attributes, there would be as many clusters as there are observations.

Neither of these extremes would be of much use. In practice, we would like to find a small number of distinct clusters in the data. Within each cluster, the attributes of each observation have more in common with each other than they do with other observations, and there is a clear distinction between each of the clusters.

There is no absolutely unequivocal way of determining the optimal number of clusters in any given data set. However, a formal tool which is widely used is to calculate a concept known as the Dunn coefficient[5]. The coefficient is calculated with the data grouped into a single cluster, into two clusters, and so on up to N clusters. The cluster number which maximizes the value of the Dunn coefficient is a reliable number of clusters to choose. A certain amount of judgment may still be involved in the case where two or even three cluster numbers have similar values for the coefficient, but the Dunn coefficient offers a helpful guide to the number of clusters to choose.

Classical clustering groups each observation, on the basis of its attributes, unequivocally into one or other of the clusters. We overlay classical clustering techniques with fuzzy logic and use fuzzy clustering[6]

Fuzzy clustering assigns each observation to some degree to *each* of the clusters. In the jargon, each observation has a membership of each cluster. Membership is calculated as a proportion, so the sum of the memberships of each observation is 1. An observation which is very typical of a particular cluster will have a membership of that cluster of close to 1, and close to zero for the other clusters. On the other hand, an observation which is a more marginal member will have a similar membership value for two (or very occasionally more) clusters. It will be allocated to the cluster for which its membership is highest, but it has attributes which place it on the margin between clusters.

[5] Kaufman, L. and Rousseeuw, P.J., *Finding Groups in Data: An Introduction to Cluster Analysis*, 1990 Wiley, New York

[6] See, for example, http://documents.wolfram.com/applications/fuzzylogic/Manual/12.html

Fuzzy clustering therefore contains more information in its output than classical clustering. The concept of membership and how this might evolve in future is a key part of the calculations of the potential range of inflation.

The UK

The data give us three different regimes. The Dunn coefficient, testing for an appropriate number of clusters, suggests either 2 or 3 are sufficient. Using two groups fails to distinguish between regimes outside war time, so we choose three groups to provide for the potential for different performance in peace time. A chart of the Dunn coefficient for different numbers of clusters is set out in the Appendix, both for the UK and for the EU data.

The values at the centre of each cluster can be calculated and are shown below.

UK	Inflation	Unemployment	Number of observations
Cluster 1	2.0	2.9	69
Cluster 2	0.3	9.0	49
Cluster 3	13.2	3.6	18

The numbers of the clusters are purely for identification and have no significance beyond this.

Cluster 1 has low inflation and low unemployment. Of the 136 years in the data set, 69 are allocated to this cluster. The cluster membership for these years is highest for cluster 1. Again for description, we call this cluster 'steady'.

Cluster 2 has hardly any inflation and high unemployment. Many years have high membership of this category, particularly in the interwar years and in the 1980s. We have labeled it 'Weak'.

The final cluster shows high inflation and moderate unemployment. Fewer years exhibit this and it has been labeled 'Disruption/Stagflation'. Years with high membership of the cluster are the war years and the years around the oil price hikes in the 1970s.

The evolution of the membership of the clusters is shown in Figure 3 below.

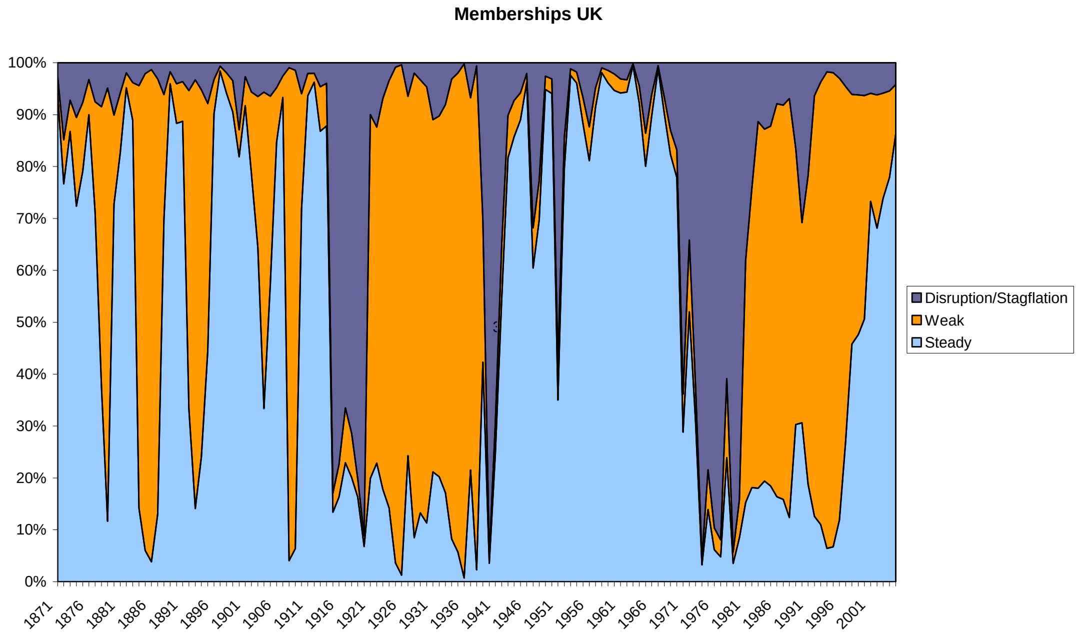

Figure 3 *Fuzzy cluster membership of each year in the UK 1871-2006 of the three clusters, 'steady, 'weak' and 'disruption/stagflation'.*

We can see, for example, the rapid growth in membership of the 'disruption/stagflation' cluster in early 1970s and the subsequent shift to 'weak'. More recently, the 'steady' regime has been growing in importance.

Over the whole period, there is a 51 per cent probability of being cluster 1 – Steady – a 36 per cent probability of being in Cluster 2 – Weak – and a probability of 13 per cent of being in Cluster 3 – Disruption/Stagflation.

3,3 The EU

The EU data also gives the potential for three different regimes using the same clustering technique as in the case of the EU data. The calculated cluster centres are shown below.

EU	Inflation	Growth	Number of observations
Cluster 1	2.5	1.5	68
Cluster 2	26.7	-4.3	10
Cluster 3	4.5	5.5	58

Cluster 1 has similar inflation to Cluster 1 for the UK, and has the largest number of observations with a high membership. However, in contrast to the UK where this cluster had the lowest unemployment, it is associated with a weak output growth performance and has therefore been labelled 'Weak'. Cluster 2 has high inflation and falling output. It has been labelled 'Disruption', since the output performance is much worse than in the UK case. Only ten years have majority membership of this cluster. Cluster 3 exhibits both good growth and highish inflation. We have labelled it 'Steady/Strong'.

Figure 4 shows how these memberships have evolved. In the 1990s, membership of the weak cluster has dominated, and indeed has been nearly 100% in all of the last five years.

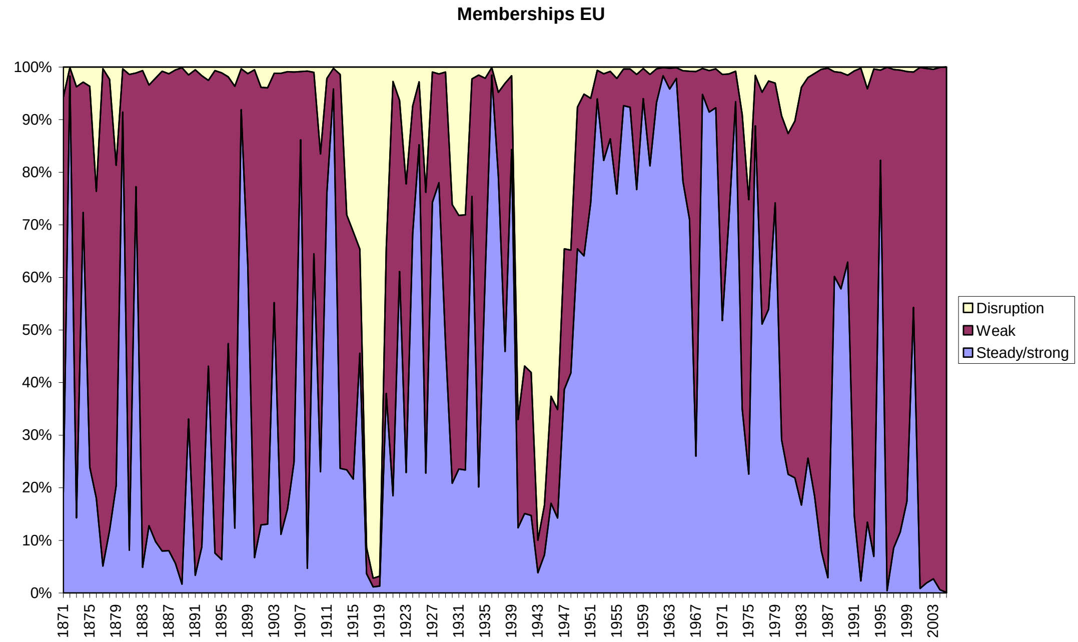

Figure 4 *Fuzzy cluster membership of each year in the EU 1871-2006 of the three clusters, 'steady/strong', 'weak' and 'disruption'*

The Disruption category dominates the two wartime periods, but is less evident after the oil price hikes than in the UK. The weak category is more prevalent than in the UK. There is a 50 per cent probability of being in Cluster 1 over the whole period, 43 per cent probability of being in Cluster 2 and 7 per cent for Cluster 3.

The central inflation rate in all three regimes in the EU is higher than that in the UK. Although some might be surprised by this result, it should be remembered that Italy has always exhibited relatively high inflation. Moreover, although Germany has had low inflation post World War Two, this has not been a feature of the whole period. In particular, all continental countries have experienced periods of very high inflation which has been relatively more unusual in the UK.

4 Projections

We now turn to using this analysis to provide projections for the likely future path of inflation and its potential distribution.

The first thing to decide is a rule for choosing the probability of each of the regimes obtaining in any given year in the future. Another way of thinking about this is to ask what period of history is most relevant to the future year in question.

A useful way of leading into this issue is to consider the innovative step taken by the Bank of England in its *Inflation Report.* The Bank provides so-called 'fan charts' of the potential uncertainty around its central projections for inflation over the next 4 years. These are based upon the judgment of the members of the Monetary Policy Committee.

At any point in time, the range of the fan chart shows the range of inflation outcomes which is judged likely to occur with a probability of 90 per cent. The Bank does not specify exact percentiles of the distribution of possible outcomes for the upper and lower points of the range. But it is judged that the chances of inflation being outside this range are only 10 per cent. A not unreasonable assumption is that the upper estimate represents the 95th percentile of the potential distribution of outcomes, so there is only a 5 per cent chance of inflation being higher, and the lower estimate is the 5th percentile, so there is only a 5 per cent chance of inflation being lower.

A striking feature of the Bank's fan charts is how narrow the range of possible outcomes is judged to be. In the February 2007 report, over a 4 year horizon the upper bound of the fan chart, the 95th percentile is around[7] 3.3 per cent, and the lower bound, the 5th percentile is around 0.8 per cent.

We are considering the Bank's fan charts in the context of thinking about what period of historical data is relevant to future projections of inflation over different time horizons. Equally, however, we can usefully ask: what period of data is compatible with the range projected by the Bank over a 4 year period? In other words, if we calibrate formally the statistical distribution of a period of historical data, what period will give us the upper and lower bounds of the Bank's fan charts at the 95th and 5th percentiles of the distribution?

The answer is that only a very short period of historical data is compatible with the narrow range in the Bank's fan charts over a 4 year time horizon. Essentially, if historical data before the early/mid 1990s is used, the 5th and 95th percentiles moves outside the range of the Bank's fan charts.

It seems quite unreasonable to assume that only such a short period of data is relevant to the future, tempting though it may be for central bankers to believe that they have finally solved the problem of inflation.

There is, of course, no unequivocally right or wrong answer in this context. But we take the view that the more distant the date in the future, the wider the range of past experience which will be relevant. Twenty years in the future, any of the three regimes is possible. It cannot be ruled out that a period of disruption can occur, either in the UK or in the EU.

There has undoubtedly been a period of general stability by historical standards over the past decade or so. This leads many people to imagine that this will continue automatically. It is well known, however, that humans find it very hard to imagine

[7] We use the phrase 'around' because the Bank does not specify precisely that these are the 5th and 95th percentiles, merely that 90 per cent of outcomes lie between them

dramatic changes and the ending of apparently stable systems or periods of time[8]. Even in the late 1980s, for example, many political experts continued to write on the assumption that the Soviet Union would be around for ever.

Since the worst case outcomes cannot be ruled out in the long term, some probability has to be attached to this potential. To capture this, we take the long term potential for inflation in the UK to be represented by the distribution of the data that we actually observe over the 136 year period. In other words, we attach an implicit probability of each of the 3 regimes obtaining in 2007 which is equal to the proportions in which they have existed over the 1871-2006 period.

We make the same assumption for the EU, with one important judgmental amendment. Figure 1 above shows that, especially in periods of 'disruption, the EU economies have been prone to experience considerably higher rates of inflation than the UK. We therefore reduce by half the weight which the 'disruption' cluster years have in the projections. In other words, over the 1871-2006 period the observations in the 'disruption' cluster account for 7.4 per cent of the total. However, in the projections, we reduce this weight to 3.7 per cent and increase the weights on the other two clusters pro rata. We are therefore making the judgment that serious disruption is less likely in the EU over the next 20 years than it has been in the historical experience of the EU countries in the period since 1871.

Although Figures 3 and 4 show that it is certainly possible to switch rapidly between regimes, in the very short term we are much less likely to see a sharp shift. For the 1 year ahead analysis (2007), we therefore attach a probability of each regime which is equal to its membership of each of the clusters averaged over the most recent past, 2004-2006. In the case of the UK, this gives a probability of the economy being in the 'steady' regime in 2007 of 0.780, in the 'weak' of 0.163, and in 'disruption' of only 0.057. For the EU, the probability of being in the 'weak' regime is close to one, at 0.961, with the probability of 'strong/steady' being just 0.037 and 'disruption' 0.002.

We extrapolate these probabilities in a linear fashion over the period 2007-2026 to give the weight of each regime in calculating the probability density of inflation in each of the relevant years[9]. In other words, we take the 2004-06 cluster memberships for 2007, and smooth these so that by 2026 they are equal to the proportions which are observed historically (scaling so that in each case the probabilities add exactly to 1).

There is a further complication with the short-term projections of inflation and their distribution. Dramatic changes can indeed occur in a very short space of time, but in general there is considerable inertia in the inflation rate. For example, writing early in 2007, many of the price increases which will feed through in costs in the next few months have already taken place, expectations of wage and salary increase have been formed with respect to the prevailing inflation rate, and so on. So in terms of calculating the range of potential inflation outcomes in 2007, certainly at the 5 and 95 percentiles, we need to take account of this.

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[8] An excellent discussion of this general point is Phillip E Tetlock, *Expert Political Judgment*, Princeton University Press, 2005

[9] The density is calibrated using the algorithm in the statistical package S-Plus, based on BW Silverman, *Density Estimation for Statistics and Data Analysis*, Chapman and Hall, London, 1986

Both the UK and EU inflation data can be described by a first order autoregressive process with a coefficient of around 0.7. In other words, the correlation between inflation in year t and in year (t-1) is around 0.7. Three years out, this gives an implicit correlation of 0.7^3 which is approximately 0.35. Five years out, the correlation is only 0.16, which can reasonably be ignored. Any inertia in the system will have, by then, have had plenty of opportunity to disappear.

So to calculate the 1 and 3 year ahead outcomes, in 2007 and 2009, we use a rule of thumb to weight the data. For 2007, we assign a weight of 0.7 to the rate of inflation in 2006, and an overall weight of 0.3 is used to scale down the probabilities of the different regimes obtaining. And for 2009 we assign a weight of 0.35 to the 2006 data and 0.65 to the regime probabilities.

The results for the UK and the EU are plotted in Figures 5 and 6 respectively.

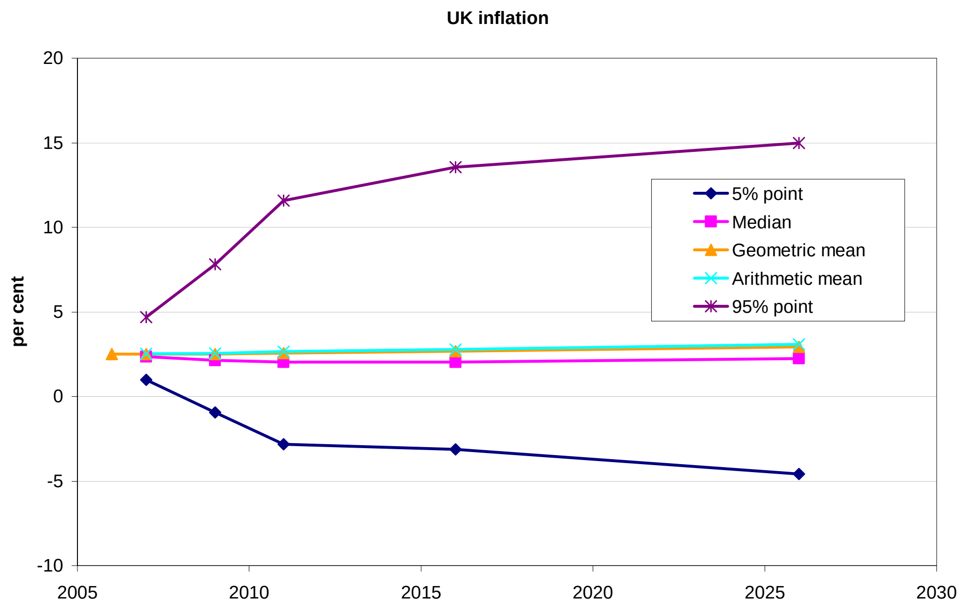

Figure 5 *Potential range of outcomes for inflation in the UK 2007-2026. The orange triangle represents inflation in 2006.*

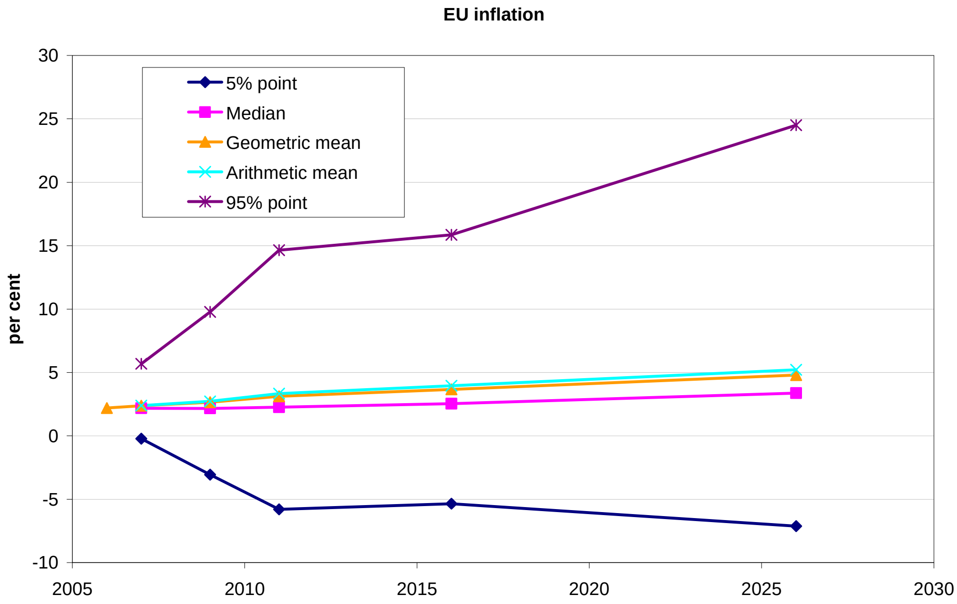

Figure 6 *Potential range of outcomes for inflation in the EU 2007-2026. The orange triangle represents inflation in 2006.*

For 2026, we obtain a much wider potential range of inflation for both the UK and the EU than many people might expect. This is mainly because of the possibility of the economies being in the 'disruption' regime at that time, a regime which is characterized by high inflation

The upside potential for inflation has generally been quite large. Although in principle prices could fall as fast as they rise, downward stickiness has been a more prevalent feature of economies than upward resistance. The distribution is therefore skewed and the arithmetic mean is considerably higher than the median. The median projection for the long run is therefore 2.2% for the UK, and 3.4% for the EU, while the arithmetic mean is 3.1% in the UK and 5.2 % in the EU.

The greater skew in the EU results reflects the greater experience of very high inflation rates in the continental countries, even when the historical weight of the 'disruption' cluster years is reduced by half..

The numerical results are set out in Table 1 below.

Table 1 Potential outcomes for inflation in the UK and the EU, 2007-2026

		2006	2007	2009	2011	2016	2026
UK	5% point	2.5	1.0	-0.9	-2.8	-3.1	-4.6
	Median		2.4	2.1	2.0	2.0	2.2
	Geometric mean		2.5	2.5	2.6	2.7	2.9
	Arithmetic mean		2.5	2.5	2.7	2.8	3.1
	95% point		4.7	7.8	11.6	13.6	15.0
	St. dev.		1.2	2.8	4.4	4.8	5.5
	Weight 1	78.0%	76.6%	73.9%	71.2%	64.4%	50.7%
	Weight 2	16.3%	17.3%	19.3%	21.2%	26.2%	36.0%
	Weight 3	5.7%	6.1%	6.8%	7.6%	9.5%	13.2%
EU	5% point	2.2	-0.2	-3.1	-5.8	-5.3	-7.1
	Median		2.2	2.2	2.3	2.5	3.4
	Geometric mean		2.4	2.6	3.1	3.7	4.8
	Arithmetic mean		2.4	2.7	3.3	4.0	5.2
	95% point		5.7	9.8	14.6	15.9	24.5
	St. dev.		1.8	4.3	7.2	8.4	10.4
	Weight 1	96.1%	93.9%	89.5%	85.1%	74.0%	52.0%
	Weight 2	0.2%	0.4%	0.7%	1.1%	1.9%	3.7%
	Weight 3	3.7%	5.7%	9.8%	13.9%	24.0%	44.3%