

**The referee makes 3 main points, and these are addressed as described below.**

**1. New section page 5**

**This deals with the referee's point**

“As the authors’ own introduction amply illustrates, this point [the instability of the empirical Phillips curve] has been made countless times before, so it is hard to see why one needs another paper to make this point again”

**And also partly covers the referee's point**

“What’s new here is the use of fuzzy clustering (on a data set that spans more than a hundred years). But the use of this technique is not well motivated. The authors find that the data can be optimally divided into 3 clusters and interpret these as different regimes. No attempt is made to explain or justify this association.”,

**this second point is also dealt with by the second addition, see below**

**new section page 5**

The instability of the Phillips curve is, as the examples above illustrate, a well-known feature of the literature. But the belief persists that a stable relationship which can be used for policy purposes can be discovered. Despite the overwhelming evidence of the instability of the relationship, researchers still continue to try to discover a stable one, using perhaps a data set which is slightly different to one used before, a slightly different relationship, a slightly different econometric approach, or whatever.

Further, and importantly, the idea that a relationship exists, albeit in a subtle and sophisticated way, is deeply embedded in the DSGE models which gained such prominence in policy analysis. Woodford (2009), for example, in an influential assessment of the state of academic macroeconomics, argues that in the context of the trade-off between inflation and real activity:

'it should be quite possible, given sufficiently accurate real-time data, to design feedback rules for policy that achieves a greater degree of stabilization than less "activist" policies. As shown by John B Taylor (1979) and a large subsequent literature, optimal control techniques can be used to design ideal stabilization policies given such a model' (p.272).

In this paper, we consider a data set which spans well over one hundred years using annual data in three major economies, the United States, the United Kingdom and Germany over the period 1871 – 2009. We apply the technique of fuzzy clustering to these data sets. The results from this technique indicate that the instability of the Phillips curve is inherent in the data, and no amount of refinement of functional form or econometric technique will overcome this problem, at least in the current state of scientific knowledge on these matters.

There are two reasons for the inherent instability of empirical Phillips curves. First, these major capitalist economies each operate at any point in time in one of three distinct regimes in inflation/unemployment rate space. The probability of remaining at time  $(t+1)$  in the regime which obtains at time  $t$  is high, but there is a probability of switching to a different regime. We obtain empirical estimates of the transition probability matrices. In other words, there can be abrupt transitions, which exhibit themselves as dramatic shifts in the Phillips curve.

## **2. New text under Table 2 page 12**

There is an important economic implication of the fact that the data segments naturally into three distinct regimes. If the data could be represented by a single cluster, the implication would be that the data we observe – a sample as it were of the population of possible data in inflation/unemployment space in advanced capitalist economies – was drawn from the same population. It would then be theoretically possible to obtain a stable Phillips curve. But this is definitely not the case. The data over time in each of the three economies is drawn from different populations.

## **3. New text under Figure 6, to the end of the main text**

**This section deals with the point “**

If the authors could show that the statistical clusters they find can be associated with economically comprehensible, distinct regimes, then it might be useful to focus on the analysis in the second part of the paper. More specifically, it would be interesting to show that the three economies have tended to be in the same regime at the same time.”

We did in fact provide information on the latter sentence in the original draft, but this is now extended

**New text**

In all three economies in the period prior to World War One, the cluster we have designated as ‘steady’ predominates, and is characterized by both low inflation and low average unemployment. The three economies were all in the same cluster for 28 of the years, and there is also a commonality in their experiences when they are allocated to the ‘weak’ cluster instead during this period.

In terms of classifying the years into one or other of the clusters, over the 1871-1914 period, out of the total of 44 observations, for the US 37 are in the ‘steady’ cluster, the main exceptions being the years from 1893 during the substantial recession experienced at that time. The recession led to a sharp rise in unemployment, but the reduction in inflation was nowhere near as marked. For Germany, 38 out of the 44 observations are in the ‘steady’ cluster, a main exception here being years in the mid-1880s when, as in the US in the 1890s, unemployment rose sharply without large reductions in inflation. fell sharply despite. The experience of the UK is very similar, with 31 of the years being in the ‘steady’ regime, and the rest being characterized by high unemployment without marked falls in inflation.

The First World War created much ‘disruption’ for all three economies, with substantial levels of inflation being recorded. The inter-war years are the least co-ordinated period of the entire 1871-2009 sample, especially during the 1920s in the aftermath of the major shock of the war and the disorganised manner in which the economies emerged from it, the UK for example recording by far its largest single year fall in GDP in 1919. International co-operation was low

throughout most of this period, with trade barriers and beggar-my-neighbour policies being actively promoted.

So in the 1920s, for example, the three economies were all in the same cluster only in 1920 (disruption) and 1929 (weak). After the initial disruption, the UK remained throughout the inter-war period in the 'weak' cluster, in other words experiencing low inflation and high unemployment. In contrast, the US in the 1920s enjoyed favourable economic conditions, with strong output growth, low unemployment and low inflation. The Great Depression was much more severe than in the UK, where the falls in output were comparable to those recently experienced in 2008/2009. This massive shock switched the US to the 'weak' cluster. Germany of course experienced both the hyper inflation of the early 1920s and an output loss in the 1930s similar to that in America. The latter shocked the economy into the 'weak' cluster for much of the 1930s.

The Second World War saw an increase in the average degree of membership of the disruption cluster, but nowhere near as marked as in the First World War. However, the period from the early 1950s to the late 1960s was marked by the dominance of the 'steady' cluster in all three economies, all of them being in this cluster in every year between 1955 and 1967.

The breakdown first took place in America, with the disruption cluster membership rising sharply from 1968 onwards. Conventional wisdom is that it was the massive rise in commodity prices during the early 1970s culminating in the four-fold rise in the oil price 1973/74 which was the major dislocator of the 'Golden Era' of steady growth, low unemployment and low inflation of the 1950s and 1960s. Cluster analysis suggests, however, that the impact of Vietnam and the loose monetary policy in place to pay for the war led to America experiencing a considerable shock in terms of its inflation/unemployment experience in the late 1960s. It was not until the oil shocks themselves that the UK was shifted into the disruption cluster. In marked contrast, Germany remained in the steady cluster throughout the 1970s. The oil price rise represented, at least in the short term, a shift in real income from the West to the OPEC economies, and the German labour force recognised much more clearly than any other that this implied falls in real wages. So the inflationary shock in Germany was contained. In the UK, there was very strong

resistance to real wage cuts, setting up a rapid wage-price spiral in which inflation rapidly exceeded 20 per cent and was only halted through large rises in unemployment.

America remained in the disruption cluster throughout the 1980s, taking a long time to adjust to the various shocks experienced, Vietnam and the first and second oil price shocks. Given that a non-trivial portion of the applied Phillips curve literature attempts to estimate relationships using US data which include the 1970s and 1980s, it is not surprising that they exhibit marked instability. By the early 1990s, America settled into the 'steady' cluster although, interestingly, the degree of membership of the disruption cluster rose from 2003 onwards, culminating in 2008 when it was the largest of the three. In 2009, the economy switched back to the steady cluster. So the cluster analysis was indicating that changes were taking place in the US from 2003 onwards.

In contrast, Germany has remained very firmly in the 'weak' cluster from 1982 onwards. The period of unification around 1990 saw the degree of membership of this cluster fall slightly, but it still remained distinctly the largest of the three.

The UK experience since the early 1980s has been more mixed. Like Germany, the UK was in the weak cluster during the 1980s and much of the 1990s, but during the latter decade gradually switched to the steady cluster, suggesting that the reforms of the Thatcher era gradually paid off.

The natural instinct of economists when confronted by evidence of a distinct shift in an important empirical relationship is to try to identify a major change which can account for this. Often, this will be successful. However, we note in this context that recent research in network theory, describing the percolation of shocks across a system of interconnected agents, suggests that it is possible for even minor shocks to have dramatic consequences (for example, Watts, 2002; Ormerod and Colbaugh, 2006). An example is the massive stockmarket crash in October 1987, for which no major cause has ever been identified.

A further implication of Figure 6, however, is that although transitions from one inflation/unemployment regime to another are relatively rare, there are persistent fluctuations

in the degrees of membership of a regime, even in periods of relative stability in terms of the dominant regime. These imply in turn that the instability of the short-run empirical Phillips curve is endemic. The factors which govern the inflation/unemployment trade off are so multi-dimensional that it is not really possible to identify them empirically. There may be periods when an estimated relationship appears to exist, but of necessity it will break down even in the absence of any major shock which might enable the breakdown to be identified.

In this context it is hard to see that there is a way of identifying periods of short run Phillips curves which can be assigned to particular historical periods with any degree of accuracy or predictability. The short run may be so short as to be meaningless and in addition the clustering shows how unpredictable transitions to new regime memberships will be. If nothing else, this analysis shows that reliance on any kind of trade off between inflation and unemployment for policy purposes is entirely misplaced.