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CORE INFLATION, SEASONAL ADJUSTMENT AND MEASURES OF THE UNDERLYING TREND*

Invited paper submitted by the Office for National Statistics, United Kingdom**

I. INTRODUCTION

1. Central Banks use core or underlying inflation measures to strip out erratic movements in prices to reveal the underlying trend. These may then be used as the target for monetary policy or as analytical tools for policy purposes.

2. There is, however, no universal definition of core inflation. Removal of erratic movements may be focussed on specific components of the headline Consumer Price Index (CPI), such as food, energy, mortgage interest payments or the impact of indirect taxes, but is also applied to volatile price movements more generally or large outliers in price movements. Other approaches involve the isolation and removal of those components of inflation which are considered to be short-term, with no impact on future economic output, or the isolation of core components which are the best predictors of future inflation.

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* Due to the late submission, this paper could not be translated.

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3. Approaches can involve a systematic deconstruction of the all items consumer price index or model-based procedures. Traditionally, model-based estimates of core inflation are seen as the prerogative of Central Banks whilst national statistics offices have focused on deconstruction methods (for instance producing an index which excludes indirect taxes) and the estimation of seasonally adjusted series with the corresponding underlying trend. This paper summarises the different approaches used and carries out a critical appraisal.

II. WHY CONCENTRATE ON CORE INFLATION?

4. From an economic perspective, in a world of perfect competition and fully flexible prices (where there is perfect substitutability) and where there is unchanged monetary policy, sector-specific shocks should lead to rapid adjustments in relative prices leaving both the aggregate price level and inflation unchanged. But as noted by previous authors, in practice such shocks do impact on measured inflation, at least in the short run and sometimes for a prolonged period. This partly reflects short-term costs that firms face in adjusting prices. It is also a reflection of measurement issues. CPIs cover only a subset of whole economy retail price movements and typically do not allow fully for the consumer substitution effects that typically follow changes in relative consumer prices.

5. In practice then, CPIs fail to distinguish between relative price movements reflecting sector-specific events and underlying price changes reflecting aggregate shocks to the economy. This gives rise to a considerable amount of statistical noise in a consumer price index due to irregular factors such as:

- Temporary disturbances from prices that have a tendency to be volatile reflecting regular sector-specific shocks, for example, seasonal food or energy prices;
- Changes in fiscal policy, for example, or the impact of indirect tax changes or subsidy levels;
- The direct effects of monetary policy decisions, i.e. changes in interest rates and mortgage interest payments;
- Exogenous disturbances, for example imported inflation, which cannot be influenced by monetary policy.

6. This noise can make it difficult for monetary authorities to fulfil their mandate to maintain a low and stable level of inflation. It is important to be able to distinguish between underlying movements in prices and temporary disturbances in that only the former may require a monetary policy response. If central banks are able to respond to a reliable core measure of inflation, monetary policy decisions are likely to be more efficient in terms of achieving a given target but with reduced volatility in interest rates, output and other real variables.

7. Unfortunately, transitory movements can only be identified with precision some time after the event. Also the headline rate of inflation is generally not under the control of the Central Bank, particularly in the short-term. In consequence Central Banks are often remitted to target a measure of core inflation or may decide to do so operationally. It is argued, for

instance, that a core inflation that is not influenced by exogenous factors is a good indicator of policy outcome.

8. Moreover, as policy changes affect underlying inflationary pressures that impact on inflation only over an extended period, Central Banks in conducting monetary policy will be targeting inflation eighteen months to two years into the future. Monetary authorities therefore must be forward-looking and will monitor a range of variables that provide some signal of inflationary prospects. Measures of core inflation itself are one input to this approach, and together with the range of other evidence, will be assessed in the context of an underlying view of how the economy operates, and typically formalised in economic forecasting models.

9. In this way, measures of core inflation are clearly useful as an input to economic analysis and forecasting more generally. They have also been used to assess the effectiveness of past policy decisions.

III. DEFINING AND MEASURING CORE INFLATION

10. As core inflation is unobservable, it is impossible to determine any single correct approach to its measurement. Furthermore, the absence of any widely agreed conceptual definition adds to the confusion, and makes it difficult to evaluate the proliferation of alternative measures that have been developed in various countries.

11. A high-level distinction may be drawn between statistical and economic model-based approaches. The latter are distinguished by their adoption of a clear conceptual basis in the identification of core inflation that is grounded in economic theory. Measurement of core price movements in this case typically involves the estimation of a behavioural relationship between inflation and its determinants in which restrictions implied by theory are imposed. Quah and Vahey (1995), for example, define core inflation as "that component of the measured inflation that has no medium to long run impact on real output", and estimate a two variable model of UK inflation to isolate the core and non-core components reflecting this prior.

12. As noted by Mankikar and Paisley (2002), the downside of such models is that the theoretical restrictions imposed are rarely uncontroversial. Measures of core inflation therefore will be heavily dependent on the particular school of economic thought that is espoused, in the Quah and Vahey case the vertical long-run Phillips curve interpretation of the co-movements in inflation and output. The detailed modelling approaches adopted will also impact on the results and a range of practical estimation issues may arise. Quah and Vahey's results, for example, might be criticised on the grounds that they ignore the measurement error component of the irregularity in the UK RPI, despite it being highly autocorrelated over periods of less than one year.

13. This paper therefore focuses on statistical approaches to the measurement of core inflation. At one level, this may involve the extraction of the trend in the aggregate CPI through averaging, seasonal adjustment or the application of a more complex filter. As noted

by Hogan et al (2001), smoothed aggregate measures have the disadvantage of diluting current with past price signals, potentially masking shifts in underlying inflation for a period. Moreover, there are few priors as to how smooth a trend measure should be. For example, if policy relevant shocks impacting on the economy are highly volatile, there is no reason in principle why a measure of core inflation should be smooth at all. Ex post evaluation of such measures against some benchmark series, typically a two-sided moving average of the CPI, is therefore both subjective and somewhat artificial.

14. The ECB (2001) equates the aggregate approach with the view that underlying inflation is defined mainly with respect to a time dimension, and reflects the persistent or lasting component in overall price changes identifiable through traditional time-series techniques. The second statistical approach is characterised as treating underlying inflation as generalised inflation, that is those price pressures common to all goods and services and excluding idiosyncratic sectoral movements. Techniques falling under this heading use component CPI price data, and may be further categorised into two groups:

- Exclusion measures, i.e. those that exclude outlying price changes or permanently exclude certain commodity components from the All Items CPI on a priori grounds; and
- Re-weighted measures, i.e. those that apply a different weighting scheme, typically in order to maximise its relevance in predicting future levels of inflation.

15. The exclusion or re-weighting approaches may also be adopted simply to derive a core measure that is less volatile than its headline CPI counterpart, although the discussion below focuses on the application of these techniques based upon some clearer conceptual rationale. Re-weighting of the CPI component indices in inverse proportion to past volatility perhaps represents, in this particular context, a more impartial and objective treatment of the sub-indices compared to a selective exclusion.

3.1 Exclusion measures

16. Bryan and Cecchitti (1993) advocate a core inflation measure that excludes individual price changes which are very different from the average. In the UK, the Bank of England has followed this approach for some time with its construction of median and trimmed mean measures of inflation. In this approach the price rises in each month are weighted by the importance of each component in the official RPIX basket - the RPI excluding mortgage interest payments - and then ranked by size. The median is the middle observation and the trimmed mean is calculated by removing the 15% highest and lowest changes in the weighted distribution and then taking the average.

17. This approach implicitly assumes that the impact of aggregate shocks may be found towards the centre of the distribution of price changes whereas sector-specific or more transitory relative price disturbances are more likely to be found in the tails. This assumption has been questioned by many authors, for example Mankikar and Paisley (2002) note that the impact of a core inflationary shock to aggregate demand might be restricted to the tails of the price distribution for a period due to the presence of staggered contracts across firms.

18. This particular deficiency is addressed by measures of core inflation that permanently exclude price changes for certain erratic components on *a priori* grounds. The motivations for such exclusions will vary, though in all cases they can be seen as an attempt to remove one-off or known changes that are not a reflection of the underlying inflationary process. For example, commodities such as food or energy, which are subject to a high incidence of sector-specific shocks, are typically removed from the core measure. The removal of one-off impacts from known changes in policy instruments is also considered desirable, for example changes in indirect taxes or interest rates. Such measures are published by most national statistical authorities, for example with variations excluding food, mortgage interest payments, indirect taxes, and other housing costs in the UK, and excluding energy, food, alcohol and tobacco in the euro area.

19. The Bank of Canada has gone further in adopting a core inflation index based on the annual average change in the CPI excluding food, energy and the effects of changes in indirect taxes (CPIxFET) as the operational guide in policy setting although the all items CPI remains the official target. This followed substantial price fluctuations for these commodities in the 1970s as a result of variable harvests and energy shocks associated with actions by OPEC. Subsequently, the Bank conducted studies to see whether alternative methods may serve the purpose better and now monitors a number of core or underlying inflation measures on a regular basis. These include a measure which excludes those components which have been most volatile in the past, including some seasonal foods, tobacco, fuels and transport, and also mortgage interest (CPIX).

3.2 Re-weighted whole distribution measures

20. Blinder (1997) identifies core inflation as the durable or persistent component of core inflation. Reflecting the main concern of monetary authorities operating in a forward-looking framework, he advocates re-weighting price changes according to their relevance in predicting future inflation.

21. In the UK, this concept has been operationalised with Cutler's (2001) persistence-weighted derivative of the all items CPI excluding mortgage interest payments (RPIXP). Expenditure categories where past data suggest that a price movement subsequently reverts to the underlying inflation rate for that category are excluded (i.e. where a first order autoregressive model of monthly prices on annual inflation rates produces negative coefficients). Where the coefficients are positive, they are normalised and used to weight the expenditure categories to compute RPIXP. For example, Cutler finds that persistence weights for petrol and oil are low relative to their actual weights in household budgets, whereas non-seasonal food merits a relatively high persistence weight.

22. The Blinder approach can be seen as a practical and pragmatic response to the monetary policy problem and does not require any a priori views to be taken, explicit or otherwise, about which components or price movements ought to be excluded from a core inflation measure. Such measures exploit persistence in inflation arising from a variety of sources including underlying price stickiness and the durability of economic shocks, although the degree to which such shocks persist will partly depend on to what extent they have been accommodated by past monetary policy. Persistence measures might therefore be considered

particularly susceptible to the Lucas critique whereby reweightings calculated with respect to past experience could prove unreliable in a new regime in which the Central Bank actively begins to target the new core measure.

23. A further approach, which can be said to complement the above, and which is promoted by Artis, Bladen-Hovell, Osborn, Smith and Zhang (1995), focuses on the early identification of inflationary turning points through the use of leading indicators.

IV. EVALUATING MEASURES OF CORE INFLATION

24. A number of authors, including Roger (1998) and Wynne (1999), have suggested a variety of desirable properties that measures of core inflation should possess. These are grouped under a number of headings below, and form the basis for the discussion that follows:

- Basic usability: authors agree that measures of core inflation should be timely, transparent and verifiable (i.e. easy to reproduce outside the Central Bank), and be credible with the general public, perhaps based on some past track record;
- Statistical properties: the measures should be resilient against errors in measurement and unbiased[1] (i.e. there is no long-run difference between core and headline or targeted inflation); they should be subject to a minimum of revision;
- Analytical properties: by capturing persistent trends in inflation and discounting volatile price movements, the core measures should provide a good guide with supporting in-depth analysis both to current underlying inflationary pressures and also future inflation levels.

25. The weight one attaches to the various criteria is of course likely to depend on the intended use of the core measure. Adoption of core inflation measures as an official or intermediate target for monetary policy in particular would place a premium on timeliness, credibility and minimum revisions. Hogan et al (2001) also emphasise controllability as a key requirement in this case. While it clearly makes sense that any inflation remit is couched in terms of a measure over which Central Banks have most control, it remains difficult to judge exactly what such a measure should be.

26. More generally, the relative usefulness of different measures depends, in part, on the relative importance given to the above criteria. For instance, an inflation measure that excludes items that historically have been the most volatile will tend to score highly in picking up persistent trends in inflation but may not necessarily score so highly on credibility. For example, the Canadian CPIX excludes fruit, vegetables, gasoline, fuel oil, natural gas, intercity transportation, mortgage interest costs and tobacco products, and the general public might reasonably view at least some of these items as key household costs.

4.1 Basic usability

27. The bulk of the approaches to measuring core inflation described in section 3 will score highly in terms of the basic criteria. Measures based on trimmed distributions, the permanent exclusions of certain items, or those re-weighted to reflect persistence can all be computed with fairly minimal production lags. Their transparency, verifiability and acceptability meanwhile are likely to vary inversely with complexity. It is probably easier to justify the permanent exclusion of certain volatile CPI components from core measures, than to explain more complex procedures relating to the distribution of price changes or persistence weights. That said, any core inflation basket that permanently excludes a significant proportion of consumer expenditure might not gain public endorsement.

4.2 Statistical properties

28. Core measures based on the exclusion of outlying price movements of erratic components from the CPI are not subject to revisions. Persistence weights ideally ought to be re-estimated periodically, particularly where there is evidence of instability, although such changes can be accommodated through annual re-weighting and chain-linking procedures as with aggregate fixed-basket CPIs.

29. Potential bias is, however, more of an issue in many cases. In the UK and elsewhere, there is a persistent divergence between trimmed distribution measures and headline or target inflation reflecting a degree of skewness in price changes. Trimmed measures generally lie below headline measures due to the preponderance of large price increases over large price reductions, although this bias might be eliminated by taking some percentile of the price distribution centred below 50%. In trimming the left tail, the ECB (2001) also highlight the concern that such measures might unduly disregard important and seemingly persistent downward price trends in higher tech sectors such as computers.

30. Since underlying trends among the various components of the CPI do diverge over the longer term, it is not surprising that the permanent exclusion measures are also subject to bias. Where this is systematic this causes few problems except perhaps in presentation, although there remains a concern that many such measures may also be removing some part of the variable trend in inflation. The exclusion of the impact of indirect taxes can cause specific difficulties depending on the policy context. In the UK, for example, indexation of real price changes for fuel and tobacco over the recent past has caused a more permanent divergence between RPI(Y) (which excludes mortgage interest payments and indirect taxes, see section 5) and RPIX. Cutler's RPIXP is also shown to be biased downwards since 1997, reflecting weak growth in prices for relatively high weighted non-seasonal food and clothing and footwear components.

4.3 Analytical properties

31. As noted earlier, there is no practical means of determining which of the core inflation measures provides the most accurate guide to the current trend in inflation. The difficulties in selecting some benchmark for ex post analysis are analogous to those encountered in identifying the core measures themselves. Measures explicitly designed to exhibit reduced

volatility will of course be smoother than the headline CPI, as will those based on exclusions, but there is no straightforward means of determining the optimal degree of smoothness required in a policy context.

32. Investigations of the predictive capabilities of core inflation measures vary in complexity. Hogan et al (2001), for example, review simple correlations between core measures and the CPI excluding indirect taxes at various future intervals up to two years. For Canadian data, the measure excluding the eight most volatile components (CPIX) is shown to outperform at longer horizons alternative measures of core inflation including the official core series (CPIxFET) and measures that downweight volatile components (CPIW) or trim the price distribution. The authors also show that CPIX and CPIW can add to simple autoregressive forecasts for the aggregate CPI, although their statistical significance in this case is not overwhelming.

33. Cutler (2001) conducts a similar analysis of core measures on UK data. RPI(Y), RPI excluding food, energy and duties, and the persistence measure RPIXP are shown to rank highest in predicting RPIX up to the two-year horizons, outperforming RPIX itself. The trimmed measures perform poorly, which the author notes partly reflects their systematic downward bias. The same measures are likewise shown to carry information over and above RPIX itself in predicting future inflation, particularly at longer horizons.

34. Mankikar and Paisley (2002) test a range of measures of core inflation in the UK against the formal cointegration tests proposed by Marques et al (2000). Where targeted and core inflation rates are found to be non-stationary, the latter authors' tests imply that core and targeted inflation should move one-for-one in the long run, and that core inflation should be an 'attractor' of targeted inflation[2] but not vice-versa. Mankikar and Paisley's results suggest that very few core measures pass all of these tests, partly reflecting bias in the core measures. Abstracting from this, a wider range of measures are shown to pass the 'attractor' tests including RPIX excluding food, alcohol and tobacco, RPI(Y) and RPIXP.

35. As the authors of all these studies note, however, some care is needed in the interpretation of the results of such tests. These partly relate to policy. If monetary policy had been set optimally such that targeted inflation had been at or close to its prescribed path, forward correlations between core measures and the target measure would be close to zero. In Marques et al's cointegration framework, targeted inflation would attract core inflation rather than vice versa. This might lead us to reject core measures that are in practice informative, although Hogan et al note that it is unlikely that any single measure would have had such a strong influence on past policy so as to invalidate the results in this way.

V. ALTERNATIVE DECONSTRUCTION METHODS: THE UK SEASONALLY-ADJUSTED RPIY

36. RPI(Y) is the UK Retail Prices Index adjusted to exclude price changes that are directly due to changes in mortgage interest payments and indirect taxation. It excludes, for instance, mortgage interest payments, VAT, council tax and excise duties. Their removal and the process of estimating weights involves a degree of estimation. Seasonally adjusted RPI(Y)

and corresponding trend estimates are calculated each month by ONS and are publicly available.

5.1 Methodology

37. Seasonal adjustment identifies and then removes the regular patterns that some time-series follow from one month to the next in the same months over successive years. In addition there are non-systematic movements due to chance or to irregular events. It is desirable to eliminate the latter in order to identify the general direction of the time-series, that is the longer-term trend, and - just as importantly - any changes in the trend.

38. In the case of the RPI, the irregular component can be relatively large due to the influence of, for example, changes in excise duty and the dates from which it is applied, and also in changes in mortgage interest payments. This can obscure the seasonal pattern. For this reason it is technically most appropriate to seasonally adjust RPI(Y) as the latter will already have had much of the irregular component taken out. This is the approach that has been adopted by ONS. The seasonal adjustment uses the publicly available X12 program developed by the US Bureau of the Census. In accordance with ONS policy the process is applied to the index numbers themselves rather than monthly or annual changes because, amongst other things, the index numbers are smoother. Further details are provided by Baxter (1999).

5.2 Usefulness

39. Seasonally adjusted RPI(Y) has been made available in response to user demand and clearly it is for users to judge how useful the figures are. Perhaps the biggest issue is the variance of the seasonal adjusted series and its vulnerability to revision, factors which do not generally impinge on the core measures described in earlier sections.

40. The variance in a seasonal adjusted series and subsequent revisions can arise as a result of two factors:

- Noise in the series;
- Uncertainty in the calculation of the seasonal adjustment factors.

41. Noise in the series can be assessed from the irregular component that is automatically estimated as a by-product of the calculation of seasonal factors. Uncertainty in the latter can be investigated by carrying out an analysis of subsequent revisions to the seasonal factors when they are re-calculated as additional data becomes available. But the usefulness of the latter analysis is limited by the difficulty in distinguishing between revisions occurring as a result of real changes in seasonal patterns and those resulting from uncertainty in the original calculation.

42. Clearly it is possible to reduce the variance associated with the calculation of seasonal factors by removing specific identifiable effects from the original series. For instance, by seasonally adjusting RPI(Y) rather than RPI, the potential difficulties in the calculation of seasonal factors which would have arisen as a result of changes in indirect taxes and mortgage interest payments are greatly reduced.

43. How does seasonally-adjusted RPIY measure against the criteria described in section 4? It is certainly resilient against errors in measurement and bias and it discounts the impact of direct government action on taxes that have a one-off transient impact on inflation. The latter means that at least some "exceptional" price movements are eliminated. Also experience suggests that seasonal patterns change very little and that as a result revisions from the updating of seasonal factors are not an issue. In addition RPIY is transparent and like all indices based on deconstruction it fits well within a family of indices and this facilitates coherent analysis.

44. On the downside, and unlike some other approaches, it is not specifically constructed to be a good predictor of future inflation levels and will not filter out all irregular shocks. The research described in section 4, nevertheless, suggests that RPI(Y) has performed relatively well as a predictor compared to the alternatives. In addition, the estimate of underlying trend that is part of the seasonal adjustment process, involves averaging of past prices and so will be a lagging indicator. In essence there is a trade off between smoothness and timeliness.

45. Finally it is, perhaps, worth reminding ourselves that in utilising seasonal adjusted data it is important to keep in mind the purpose of seasonal adjustment and that its value is enhanced both by a common sense user approach and a good technical understanding of the mathematical techniques deployed. This is, of course, also true of other techniques and perhaps more so for those such as "core" inflation which are less precisely defined in economic or mathematical terms and are not so universally recognised, although more so than a few years ago.

VI. CONCLUSIONS

46. The construction of "core" or "underlying" inflation measures are seen as providing more accurate representations of the general trend in consumer prices than "headline" measures. They are used either as inflation targets or as analytical measures to help inform macro-economic policy and actions. A measure of inflation, based on the trimmed-mean or median, or the permanent exclusion of relatively volatile components can offer a simple, reliable and transparent method for estimating underlying inflation and the impact of relative price disturbances on the consumer price index. Stochastic approaches based on the construction of an index that focuses on those elements of consumer expenditure that are the best predictors of future inflation can also be useful although such indices can suffer from unreliability if the underlying model is inadequate so are technically more challenging in their construct. Seasonal adjustment and trend estimation based on a measure where "exceptional" price movements have been excluded, has the advantage of being less judgemental than some approaches (although judgement does arise in the seasonal adjustment settings). It is also relatively robust but suffers from an implicit time lag.

47. The core features of all these measures are that they provide a better signal than the headline figure of inflationary pressures in the economy. Whilst there is no consensus in the literature on what approaches are most informative and of best practical use in monetary policy they can all play an important role. Motivated by these arguments, managers of monetary policy often turn to a range of measures. In these circumstances it is important that

users understand the conceptual basis of the different measures, their robustness in construction and how they inter-relate.

VII. ACKNOWLEDGEMENTS

48. This paper draws heavily on work carried out by others in this area and in particular papers by Hogan, Johnson & Laflech (2001), Cutler (2001) and Mankikar and Paisley (2002). Detailed references are given below. The author would also like to express his thanks for the useful comments provided by David Roe, of the Office for National Statistics, on an earlier draft. The opinions expressed in this paper are those of the author.

NOTES

[1] Bias is mainly a presentational issue if it is systematic.

[2] That is to say that actual inflation should converge in the long run to core inflation through the latter being a good predictor or lead indicator of the former.

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