## The use of fixed effects when estimating for individual Local Authorities (LAs)

Previous work developed the approach to estimating for individual LAs within an estimation area. The work concluded that in most cases stable and efficient estimates would be achieved via a synthetic model that cascaded down the adjustment within age-sex by hard-to-count groups. However, in scenarios with very specific local authority differences, the fixed effect approach used in 2001 performed better as it was able to distribute the adjustment to reflect more closely those LA specific differences.

**Why will LA specific effects occur?**

Estimation areas have been pre-defined by grouping contiguous LAs to ensure sufficient CCS sample (previous work concluded there was little benefit from non-contiguous groupings as a starting point). However, we will use information from the census fieldwork MIS to alert us to the possibility that LAs within an estimation area are likely to have very different coverage. This may lead to a re-grouping of LAs within a wider area to improve the efficiency of estimation although it will not be possible to do this for all differences, only those that are extreme. When a re-grouping (post-stratification) does not happen, the information will still alert us to the possibility that, even after controlling for hard-to-count and age-sex distributions within the LAs, differences in coverage will still exist. In other words it gives qualitative information suggesting the fixed effects model may perform better.

**Testing the significance of the Fixed Effects**

The LA level fixed effects model is a regression model with no intercept fitted using weighted least squares. Using the standard output we can therefore test the overall significance of the fixed effects but this is sensitive to the model assumptions holding. However, the decision to adopt the bootstrap for estimation of variance allows us to apply the fixed effects model within the bootstrap and output the empirical distribution of the LA fixed effects and estimate their associated standard errors, without relying on the variance assumptions of the model. Further, we can compute the empirical distribution and standard error for any combination of the fixed effects. Therefore, we can test the significance of the difference between each of the fixed effects (we are using the sum-to-zero constraint) as evidence of important LA effects. When the null hypothesis of no effect is rejected for one difference (p-value less than 0.05 on a two-sided test)[1] we will adopt the estimates based on the fixed effects, otherwise we will stick with the simpler synthetic estimates.

**The overall decision**

The testing approach makes it clear, from a statistical perspective, when we will definitely apply the fixed effects model. However, there will be a grey area where at least one of the p-values from the comparisons is ‘small’ at below 0.1, but none are below the critical value chosen at 0.05. This is likely to be a particular issue in an estimation area with a higher number of LAs due to the adjustment to p-values for multiple comparisons[1]. Where we have supporting evidence from the census fieldwork MIS that an LA within the estimation area has experienced different coverage, and this links to a p-value below 0.1, the final decision on the use of the LA fixed effects will be part of the quality assurance of the estimates.

[1] Given there will be multiple comparisons, we will adjust the p-value to reflect this using a simple bonferroni correction. In some cases with only three or four LAs this will make little difference but some estimation areas have nearer ten LAs and in those situations it will make an appreciable difference.