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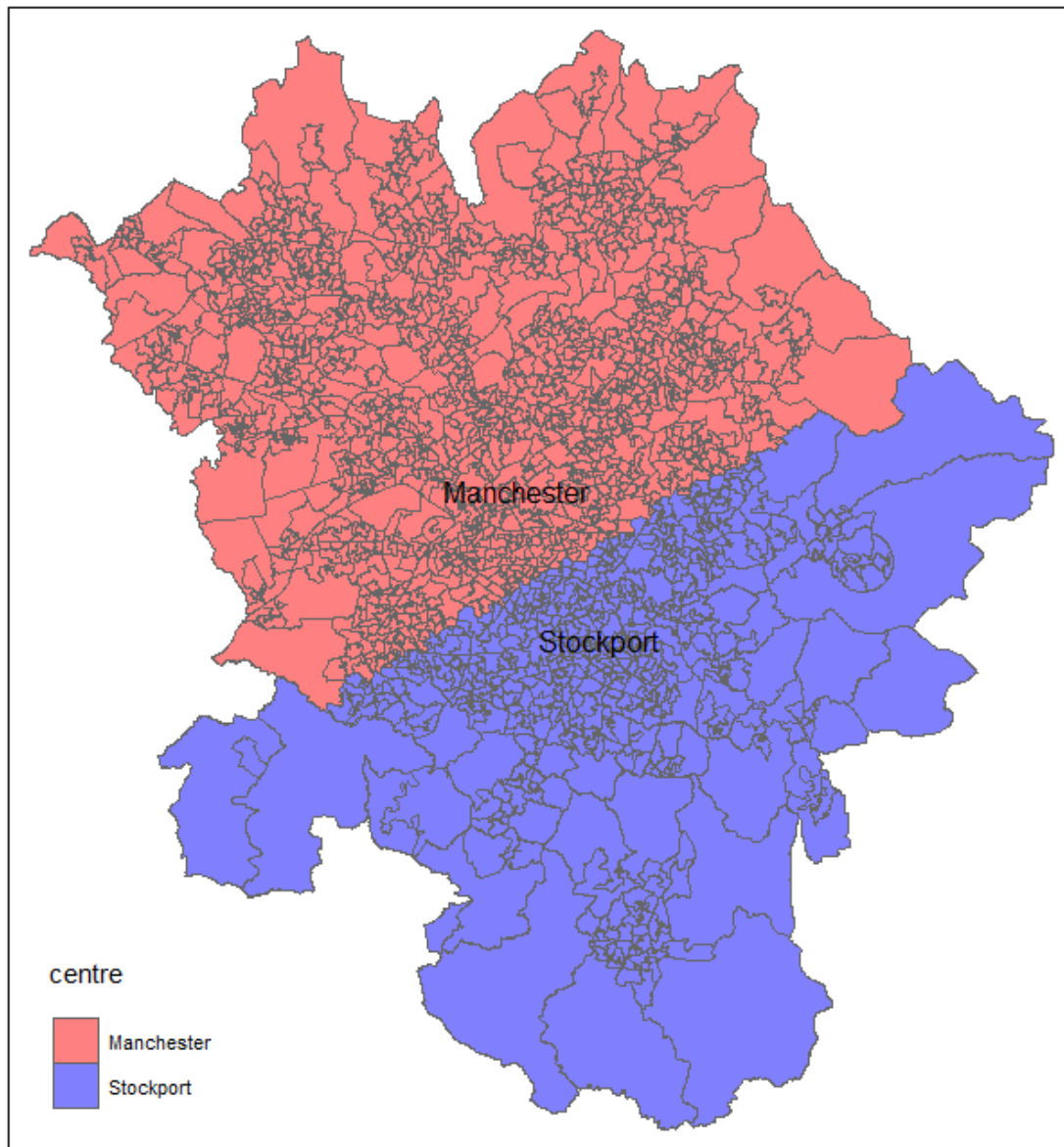
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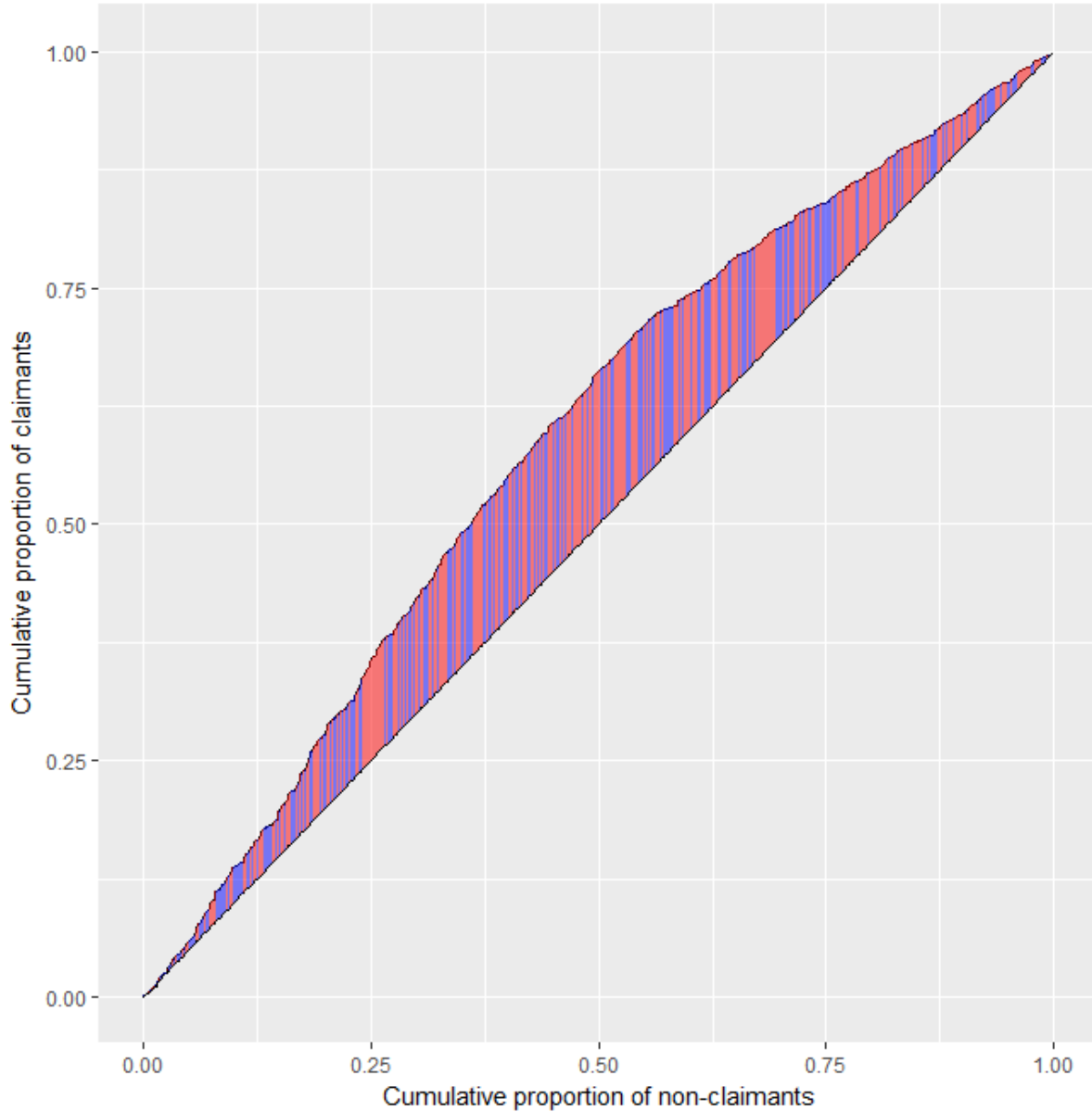
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## Properties of the generalised RCI

In the case of multiple centres, it is possible to group zones by their nearest centre point and to decompose the contribution that each centre point makes to the overall RCI in the TTWA. As an example, we split Manchester TTWA into areas closest to Manchester (red) and Stockport (blue).



We can visually represent the contribution that zones closest to each group make to the overall TTWA RCI:



The total RCI is simply the area between the curve and the 45 degree line of equality in the figure (divided by 0.5). The contributions of zones closest to Manchester is simply the sum of the area in red (divided by 0.5).

Let  $C_k$  denote the centre that closest to zone  $k$  where  $C_k = 1, 2 \dots M$ . For the groups of zones where  $C_k = m$ , the contribution that the group makes to the RCI is:

$$RCI_m = \sum (b_i - b_{i-1})(a_i + a_{i-1}) - \sum (b_i + b_{i-1})(b_i - b_{i-1})$$

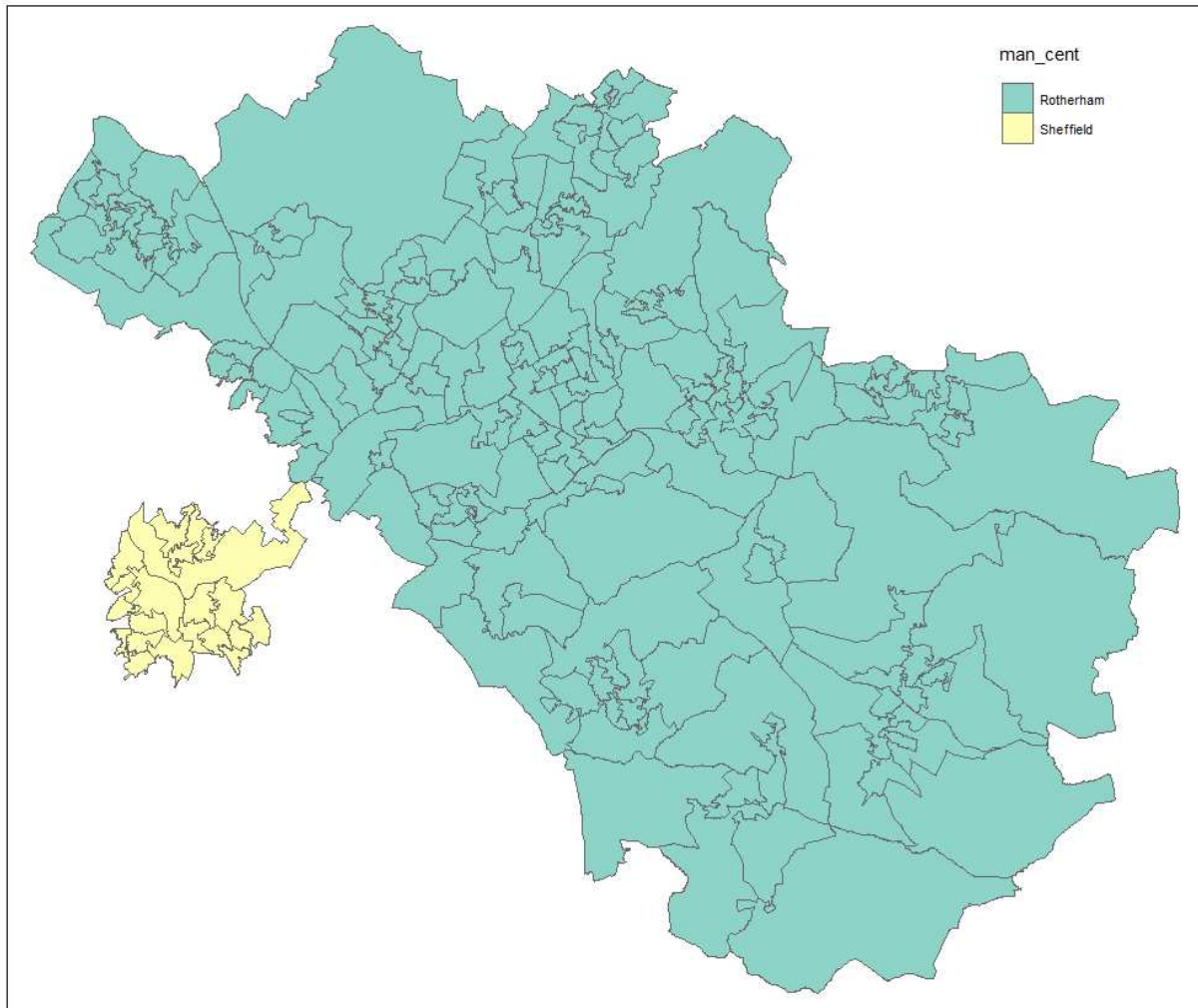
Where the overall RCI can expressed as:

$$RCI = \sum_{m=1}^M RCI_m$$

Note that the above formula shows that the overall RCI in a TTWA is not equal to the weighted average of the RCI calculated using different sub-areas within a TTWA. As an example, the RCI for Sheffield and Rotherham TTWA is not equal to average of the RCI calculated using just zones closest to Sheffield and the RCI of zones closest to Rotherham. In practise, it can be close but we will use an extreme example to show why this may not be the case.

Shefford and Rotherham is a TTWA created from the Sheffield TTWA which includes all LSOA closest to Rotherham and inner city Sheffield (i.e. any zones within 2km of Sheffield city centre). We refer to the latter as Shefford. This fictional TTWA shows how the concept of centralisation is relative. A neighbourhood 1km away from Shefford city centre is considered far away relative to other neighbourhoods in the *same city or sub-area* (since distance from city centre is max 2km). However, that same neighbourhood in the context of the entire TTWA will be relatively centralised.

Using 2001 data on jobseekers, overall unemployment in Shefford and Rotherham is relatively centralised (RCI = 0.25) as a high proportion of jobseekers live within 2km of an urban centre (34.7%) compared to non-claimants (14.9%). However, the individuals parts of the TTWA—Shefford and Rotherham—have far lower levels of centralisation at 0.03 and 0.15 respectively. In the case of the Shefford sub-area, unemployment is almost evenly distributed in its near and far zones.



Sheffield and Rotherham is a fictional TTWA which serves as an extreme example that shows why the averaged RCI of sub-areas in a TTWA is not equal to the RCI for a TTWA.

## Comparison between FUA and TTWA

### Introduction

This is a sensitivity analysis looking at whether different results are obtained if Functional Urban Area is used as the areal unit definition of economic area instead of Travel to Work Area. To avoid excess duplication, we concentrate on the results for poor residents as defined by IMD income deprivation (and thus only on results for England).

### Data

Functional Urban Areas (FUA) were created by the OECD and European Commission and allows for consistent definitions of an urban area across countries. FUAs consist of at least one core city with a

population of over 50,000 and its surrounding commuting zones based on population density and commuter flow data (OECD, 2012).

We have 46 FUAs in England and Wales. 129 TTWAs have some areas that fall within a FUA boundary. The average TTWA used in the main paper has 327,000 residents whilst the average FUA has 955,000. In summary, FUAs are usually larger than TTWAs and can include several TTWAs within their boundaries. For the purposes of computing inequality indices, we assign LSOAs to FUA based on the location of their population-weighted centroids. Otherwise, all other calculations of the inequality indices remain unchanged from the main paper.

## Results

We find that poor residents were on average more likely to be concentrated around a) urban centres (RCI: 0.15 to 0.12), b) employment opportunities (0.21 to 0.17) and c) common amenities (0.21 to 0.18) in both 2001 and 2011.

There is a strong correlation between RCI change and RAE (0.77) and moderate between RCI and RPA (0.54). Larger FUAs have experienced greater negative changes in RCI (-0.25), RPA (-0.50) and RAE (-0.28). We note that only the correlation between change RPA and population is statistically significant ( $p < 0.01$ ). However, we have reason to believe the lack of statistical non-significance for other relationships can be attributed to lack of statistical power (i.e. 37 FUAs compared to 149 TTWAs).

Overall we find that the main results of the paper do not change if we use FUA instead of TTWA. We find similar results using jobseekers instead of low income residents.

## References

OECD (2012) *Redefining 'Urban': A New Way to Measure Metropolitan Areas*. DOI: <https://dx.doi.org/10.1787/9789264174108-en>.