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**Analysing socio-economic change using a time comparable geodemographic classification: England and Wales, 1991-2011**

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**Abstract**

Geodemographic classifications are used to understand social phenomena. Within the private sector, for business planning accounting for underlying spatial differences in economic, social and demographic composition of geographical areas. In the public sector geodemographic classifications are used in health, local governance and social research. Bespoke geodemographic systems help public health authorities to target neighbourhoods most at need of health campaigns.

Geodemographic classifications are invariably cross-sectional and static. Having comparable geodemographic classifications over a period of time will help demonstrate changes in socio-economic and demographic structures. A time-comparable geodemographic scheme can bring out changes in multivariable compositional characteristics which are otherwise hidden by cross-sectional measures. This paper reports on variable selection, the conversion of inputs to a consistent geography and the creation of directly comparable geodemographic classifications of small areas across England and Wales for 1991, 2001 and 2011. Changes and stability in area characteristics are then analysed.

The results show that most neighbourhoods are allocated into the same area type over time. Where there is change, this can be themed as: Socio-economic polarisation, characterised by a decrease in neighbourhoods found in the middle of the socio-economic spectrum, with an increase in number of areas at either end; Growth in the number of neighbourhoods with non-White ethnic residents, mainly Black ethnic minorities and Asian based communities and; Reorganisation and increase in classifications relating to urban areas, signalling development or growth of metropolitan areas.

**Keywords**

Geodemographics; Census; England & Wales; Time Comparable Classification

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## 1 Background

Socio-economic and demographic characteristics of geographic locations change over time through the flux of residents and changes in the built environment (Gale & Longley, 2013). Lifestyles and family structures evolve, affecting patterns of household composition, fertility, mobility, social networks and leisure (Garonna & Triacca, 1999). Exposure to immigration and increased technological communication allow for the global circulation of news, fashion, music and other forms of culture can all impact society. Measuring and assessing any change is an important part of social research since this: enables targeted funding and policy intervention; allows policy makers to understand which social interventions have been effective; gives a platform for replication of effective and positive processes in other communities and; permits the creation of new theories of social change (Batliwala, 2006).

Numerous studies use composite indexes to capture the various socio-economic factors that characterise an area. The use of geodemographic classifications for distilling socio-economic data for geographical areas dates from the 1970s within both the private and public sectors. Geodemographics is a progenitor of the social research of Charles Booth in the late 1800s (Harris et al. 2005) and the Chicago School of Urban Sociology in the 1920s and 1930s (Pfautz, 1967). Geodemographics is underpinned by the theory that facets of human geography have repetitive patterns, with non-contiguous geographical areas having similar social features (Weiss, 2000). Harris et al (2005, p.225) described geodemographics as "the analysis of socio-economic and behavioural data about people, to investigate the geographical patterns that structure and are structured by the forms and functions of settlements". This conveys the central theme of geodemographics: clustering of areal units into homogenous groupings that are similar to one another and distinct from the other groupings (Tsapanos et al. 2015).

There is a growing realisation that geodemographics can be used to understand social phenomena beyond aspatial summary measures (Sabater, 2015). A major advantage of geodemographic classifications is their ability to simplify complex and large data sets into values that are easily understood (Voas & Williamson, 2001). In the private sector, geodemographic segmentation has been employed to gain a greater comprehension of underlying spatial differences in economic, social and demographic composition of geographical areas, enabling effective targeting of resources (Liu & Ong, 2008). Applications within the public sector are varied, with geodemographics being used in health, local governance and social research (Shelton et al. 2006; Abbas et al., 2009). Petersen et al. (2011) evaluated the use of classifications to make inferences about patterns of local health needs with

a bespoke geodemographic system to help public health authorities to target neighbourhoods most at need of health campaigns.

Many authors warn about drawbacks of geodemographic classifications (e.g. Voas & Williamson, 2001; Harris et al., 2007; Singleton et al., 2016) including that labelling an area can imply that all residents are like that label (the 'ecological fallacy'), that classifications are only applicable for the geographical units for which they are developed (the 'modifiable areal unit problem'), that an area allocated to one area type may itself be more or less atypical of that type and, most pertinent to this paper, that areas may change and classifications can become dated. In this regard, geodemographic classifications are invariably cross-sectional and static. If geodemographics are the study of 'where people are' (Sleight, 1997), then having comparable geodemographic classifications over a period of time will help demonstrate changes in socio-economic and demographic structures. Norman and Darlington-Pollock (2017) used a time comparable deprivation index (using four input variables) to highlight changes in social inequalities. A time-comparable geodemographic scheme could bring out changes in multivariable compositional characteristics which are otherwise hidden by cross-sectional measures.

Despite clear advantages, the socio-economic dynamism of geographical areas over time has not received adequate attention within the geodemographic literature (Ashby & Longley, 2005; Longley, 2012). Static classifications will become less useful over time due to the changing socio-economic composition of areas over time (Singleton et al. 2016). It is into this gap that this study fits. The aim is to develop a general purpose geodemographic classification which captures socio-demographic changes in neighbourhoods over time and then to use this classification to assess whether characteristics are ingrained or represent changing social structures. This to be achieved first by processing raw data in a manner similar to that used to calculate comparable deprivation over time (Norman, 2010; 2016; Norman & Darlington-Pollock, 2017) and then to utilise the changing geodemographic method defined by Vickers (2010). This paper reports on the variable selection, the conversion of inputs to a consistent geography and the creation of a directly comparable geodemographic classification of small areas across England and Wales for 1991, 2001 and 2011. Changes and stability in area characteristics are then analysed.

## 2 Methodology

When developing a geodemographic classification, zones are linked to other zones to form a virtual 'cluster' on the basis that areas within one cluster are more similar in multivariate characteristics to each other than they are to those areas belonging to any other group. Areas allocated to a cluster may be contiguous or may be at a distance. An aim of the classification is to achieve good 'discrimination' / 'segmentation' of areas by their characteristics such that for all the zones in the study region, every

zone is allocated to one cluster of characteristics. A commonly used method is 'K-means clustering'. The challenge here is to allocate areas to a classification which captures that places may change their multivariate characteristics over time. In a cross-sectional classification, an area will be given one label to describe what is stereotypical about that area and others in the same cluster. Here, areas will be given a label at successive time points and these labels should portray whether the place has changed its characteristics or stayed the same.

The methodology is in three sections: selecting relevant census variables for the years 1991, 2001 and 2011; converting the census data for these years into a common geography; and creating the geodemographic classifications which capture change and stability over time. The geography of this 1991 to 2011 classification will be the 2011 specification of the Lower Super Output Areas (LSOA) for England and Wales; a commonly used contemporary geography in social and public sector analyses. There is need to select variables which are available in sufficiently similar definitions at each census and for the lowest level of the census hierarchy of geographies (Norman & Riva, 2012; ONS, 2017). These needs are both to enable comparison over time and so that conversion to a common geography is reliable. There are trade-offs and compromises involved.

### 2.1 Variable Selection

Data selection is a vital part of area classification methodology and must be done with care and consideration. The input data here will be obtained from the 1991, 2001 and 2011 Censuses. Census data have nearly complete coverage and are sufficiently reliable and trustworthy (Rees et al. 2002). The aim of variable selection is to have a minimum number of variables that represent the main dimensions of the data (Bailey et al. 1999). The variables selected for consideration here cover the domains of age-structure, socio-economic, cultural, household and housing. Variable selection is also based on availability at the lowest level of geography to enable reliable conversion between geographical units. Thus, we obtain census data for 1991 at Enumeration District (ED) level and for 2001 and 2011 at Output Area (OA) level. Some variables have been collapsed to ensure that numbers are not too small and to achieve consistent definitions between the various census years since often the number of variable categories has changed over time.

For initial appraisal, the census variables were converted into percentages (in their original geographies) and the 2011 variables were correlated to assess potential multicollinearity / redundancy. The variance of each distribution was tested to highlight any homogenously distributed variables that would not add value to the classification (Ojo et al. 2013). The list of variables selected is in Table 1.

< Table 1 about here >

Educational achievement has been analysed using geodemographics (Singleton et al., 2012). Education is included for change over a recent time period in Singleton et al. (2016) but not in the older work by Vickers (2010). Ideally, we would include a variable on education and its omission from our classification is a compromise. As an input for our work, although education is available for Output Areas in 2001 and 2011, it is only available at ward level in 1991. Since wards are generally larger in extent than LSOAs, education was not included since conversions to the 2011 LSOA geography would introduce error (Norman & Riva, 2012).

### 2.2 Census Geography Conversion

Norman et al. (2003) recognise the potential that linking census data over time has and highlight the boundary change issues hampering studies. Without a stable geographical unit, it can be difficult to understand if the changes over time are genuine or result from shifts in geographical boundaries. A geographical conversion table (GCT) was created using a method defined by Norman et al. (2003). For this study, data were harmonised to the 2011 Lower Super Output Area (LSOAs).

GCTs are created by first generating a link between the 'source' geographies, which here comprise the Enumeration Districts (EDs) in 1991 and the Output Areas (OAs) 2001 and the 'target' 2011 LSOA geography. These links are provided by the National Statistics Postcode Directory (NSPD) for the same year as each source geography. Once this link is created a conversion weight can be calculated to distribute the population within the source areal unit to the target areal unit. Conversion weights are calculated by summing the address count at each postcode within the intersection between the source areal unit and the target unit and dividing this by the total number of postcode addresses found within the whole source unit. These weightings are then applied to raw census population or household counts to determine the distribution in the source - target intersection. Finally, the data are reaggregated into the target geography.

The raw counts (numerators and denominators) in the original 1991 ED and 2001 OA units have been converted here to the 2011 LSOA level for England and Wales. Conversion from smaller to larger units is found to be reliable (Norman & Riva, 2012). Data for 2011 does not need conversion.

### 2.3 Clustering

#### 2.3.1 K-Means Algorithm

K-means is a relatively simple non-parametric clustering method that has been at the forefront of cluster algorithms for the last 50 years (Naldi & Campello, 2015). This is primarily because it is good at dealing with large data sets (Vickers, 2010), it is adaptable and scalable and relatively simple to understand (Naldi & Campello, 2015). It has commonly been used within geodemographics with numerous examples in the literature, such as Vickers & Rees (2006) and Durduran (2015).

Before clustering can begin, unusual distributions and outliers need to be highlighted and amended or excluded. A small number of extreme values or a skewed distribution could have adverse impacted and affect the quality of the classification (See & Gibson, 2006). Therefore, all variables were converted to percentages and then normalised to a value between 0 and 1 (by range standardisation), to ensure that each variable has the same weight (Vickers, 2010).

### 2.3.2 Cluster Membership Count Selection

The k-means algorithm requires a manual selection of an initial number of clusters with no optimal number of clusters (Debenham, 2002). To determine an appropriate number of clusters the clustering algorithm was run for 2011 using cluster counts of 2 to 30 (Debenham, 2002). Each clustering solution was then compared using a number of tests, namely: the variance of the number of members within a cluster; the range between the maximum and the minimum number of members within a cluster; the average Euclidean distance to cluster centre for each data point in cluster; and the number of clusters with less than one quarter of the number of members (number of LSOAs) than the average count of cluster members. These tests ultimately assess the distribution of data: an even distribution is ideal due to it lowering the risk of outliers (Vickers & Rees, 2006), which would result in an unstable classification (Singleton & Longley, 2009).

To evaluate these tests, each cluster model was ranked for each test, with each rank being summed together (Table 2). There are several cluster solutions with potential; 21, 13 and 10. Having 21 clusters would be too many to give a meaningful classification. Cluster solutions 13 and 10 were mapped to gain an understanding of the geographical distribution and the prevailing characteristics of each cluster within both solutions were assessed. It was determined that a 10-cluster solution was the most appropriate.

< Table 2 about here >

For the creation of three classifications which are comparable over time, each 2011 LSOA unit will need to have cluster values for each year 1991, 2001 and 2011 assigned to it. Changes over time can then be determined by the cluster reassignment for each area. The steps defined by Vickers (2010) were followed. In this process the variables for both 1991 and 2001 were clustered using the k-means algorithm. However, instead of a random initial starting point, the cluster centroids produced for the 2011 classification were used (a hypothetical example can be seen in Figure 1). The data points were then assigned to the nearest cluster centre, but, unlike the standard k-means algorithm, this is where the process stops. The iterative process of cluster centroid reassignment to reduce the Euclidian distance does not take place. Consequently, each LSOA was assigned three cluster membership values. This process ensures the 1991, 2001 and 2011 classifications are comparable, as they are all built from consistent input variables and the same cluster centroids.

< Figure 1 about here >

### 2.3.3 Cluster Labelling

The labelling of clusters is an important aspect of the classification process. The labels given to the clusters should be descriptive of the major themes but not be potentially offensive (Vickers & Rees, 2006). The descriptions should not be so narrow as to describe only those at the very centre and potentially represent a proportion of the cluster incorrectly (Vickers & Rees, 2007). However, if the description is too broad then it becomes vague and loses meaning. To provide and aid in the determination of labels, z-scores were used to highlight the key aspects of each cluster. Relative presence of a variable is indicated by a positive z-score and relative absence by negative z-scores.

The classifications for 1991, 2001 and 2011 are mapped in Figure 2. Spider graphs of the relative absence and presence of input variables for each cluster are in Figures 3a and 3b and these were used to inform the cluster labelling. The cluster labels provide some meaning, but are only indicative.

< Figures 2 and 3 about here >

Our results will be compared with two other time comparable census-based schemes. As noted above, Vickers (2010) developed a scheme for comparing 1991 with 2001. This was for England for the 2001 specification of the Output Area geography and used 22 input variables at both time points classified into seven cluster groups. Singleton et al. (2016) aimed to assess the stability of geodemographic cluster assignments between 2001 and 2011 in England for the 2011 Output Area specification. They used 55 input variables grouped into an eight cluster solution. Although there are differences in national coverage, small area geography and some method details, we expect our findings for the Lower Super Output Area geography in England and Wales for 1991, 2001 and 2011 to have commonalities with broad patterns found by Vickers (2010) and Singleton et al. (2016).

## 3 Results

Table 3 reports the total changes between cluster memberships between 1991 and 2011 which indicates that the majority of LSOAs do not change classification. This is understandable because changes in area characteristics are only likely with considerable redevelopment or social change (Oxford et al. 2002). The extent of change is less over a 10-year period, with change being more apparent over the20 year time period. This fits with the argument that, for urban change, 35 years is “not a long time” (Hulchanski, 2010, p.7). Of the LSOAs that did change classification, the majority are within urban areas (ONS, 2017). This is consistent with Bromley et al. (2007) who explained that, in response to de-urbanisation of cities in the 20th Century, governments around Europe, including the UK, have introduced policies that encourage development of urban centres and brownfield sites. This, along with potential gentrification and urban renewable projects all feed into the likelihood that urban areas are less socio-economically stable than more rural areas. Between 1991 and 2001, Vickers (2010) found that 70% of areas remained in the same group and between 2001 and 2011, Singleton et

al. (2016) had 60% of areas in the same cluster but of those which changed, as with our findings, the majority were in urban areas.

< Table 3 about here >

Figure 4 illustrates the distributions of LSOAs by cluster membership for the years 1991, 2001 and 2011. There is clear growth in Mixed Metropolitan (C1), Student Sprawl (C2), Constrained Social Renters (C3), Countryside Affluent (C6), Stretched Multi-Cultural Communities (C7) and Terraced Asian Communities (C9) classifications. Conversely, there are reductions in LSOAs defined as Money Conscious Terraces (C4), Middle Aged Achievers (C5), Established Suburban Fringes (C8) and Endeavouring Young Urban Renters (C10).

< Figure 4 about here >

Two matrices were created to investigate these transitions. The first illustrates the counts of absolute changes between classifications (Table 4), with the second showing the net change, accounting for changes in both directions (Table 5). As above, these tables highlight that large numbers of LSOAs do not change their cluster membership. However, between 1991 and 2001 and between 2001 and 2011 relatively large numbers of LSOAs change classification from Middle Aged Achievers (C5) to Countryside Affluent (C6). In both time periods this is one of the most common classification changes and contributes greatly to the growth of Countryside Affluent (C6). Much of the growth in Constrained Social Renters (C3) are transitions from Money Conscious Terraces (C4).

< Tables 4 & 5 about here >

Direct comparisons are not possible but similar socio-demographic pictures emerged from Vickers (2010) who showed between 1991 and 2001 an expansion of areas labelled as 'Urban Melting Pot', 'Out in the Sticks' and 'Down and Out' The largest change is from 'Middle Class Achievers' to 'Out in the Sticks' (suggesting counter urbanisation). Between 1991 and 2001 'Working Class Endeavour' is a contracting group which Vickers (2010) suggests could be a breakdown of traditional working class areas but with some areas apparently improving but others falling into the 'Down and Out' group. Singleton et al. (2016) showed that, between 2001 and 2011, there were changes for less deprived and rural area types with some 'Professional Prosperity' areas changing to 'Country Living and Retirement'. 'Intermediate Areas' gain from 'Blue Collar Suburbanites' (implying upward social mobility). 'Hard up Households' see changes to 'Suburban Diversity' indicating the expansion of non-White groups.

## 4 Discussion of broad patterns

The results above show that most neighbourhoods are allocated into the same or similar area type over time. Where there is change, this can be themed as: Socio-economic polarisation, characterised by a decrease in neighbourhoods found in the middle of the socio-economic spectrum, with an increase in number of areas at either end; Growth in the number of neighbourhoods with non-White ethnic residents, mainly Black ethnic minorities and Asian based communities and; Reorganisation and

increase in classifications relating to urban areas, often the ‘inner city’, signalling development or growth of metropolitan areas.

### 4.1 Polarisation

Results from our 1991, 2001 and 2011 changes can be interpreted as a potential polarisation. Classifications Money Conscious Terraces (C4), Middle Aged Achievers (C5), Established Suburban Fringes (C8) all see a contraction in the LSOA counts. This is in contrast to Constrained Social Renters (C3) and Countryside Affluent (C6) which see an increase between 1991 and 2011. The four shrinking classifications could be classed as those that which comprise populations found within the middle of the socio-economic spectrum. The two growing classifications are book-ending this spectrum, with Countryside Affluent (C6) containing more advantaged members of society and Constrained Social Renters (C3) representing more disadvantaged members. However, with Countryside Affluent (C6) being one of the most common classifications, the residents contained within may have a wide-ranging number of characteristics. This socio-economic spectrum is subjective and relatively crude but a useful device for illustrating that a key theme in the changes is polarisation: a squeeze in the classifications representing the middle of society, with growth at the top and bottom.

This notion is supported by the classification changes noted previously. Between 1991 and 2001 the most common classification change was from Middle Aged Achievers (C5) to Countryside Affluent (C6). Between 2001 and 2011, the most common was from Money Conscious Terraces (C4) to Constrained Social Renters (C3). The second most common was from Middle Aged Achievers (C5) to Countryside Affluent (C6). This demonstrates a common theme in both decades, although there is an increase in those transitioning into the lowest category between 2001 and 2011. The growth of Countryside Affluent (C6) indicates that some residents may be seeking a better life in the outer suburbs and in the more rural communities, or as Vickers (2010, p.11) puts it, these areas are “becoming the preserve of the elite”. However, within this study Countryside Affluent (C6) appears to be a broader classification, due to the number of LSOAs it covers, therefore cannot be classed as an ‘elite’ category. At the other end of the scale, there is an increase in those who are vulnerable, with a growth in LSOAs classified as Constrained Social Renters (C3).

The changes highlighted evidence of a polarisation of society, suggesting that the social change occurring is one of division, indicating a lack of choice in where individuals can choose to live (Vickers, 2010). Those who are least fortunate are kept separate from other groups and are unable to move up or out, leaving them in areas that are treated with distain by those who chose not to live there (Byrne, 2005). On the other side, those who are better off could be restricted by their negative perceptions of the ‘other’ areas, thus dissuading themselves from moving (Clapson, 2003). These

issues could be propagated by external events, such as an economic recession and the available support and investment given by governments, councils and private companies.

The polarising effect observed here has been evidenced in other studies, notably Dorling and Rees (2003) who argue that society in the UK is continuing to polarise at many levels, in areas such as wealth, employment and the locality of married couple. The results presented in Dorling et al. (2007) illustrate a reduced number of areas that the authors term 'average' and a growth of each end of the wealth spectrum. Fahmy et al. (2011) found there was a reduction in the number of people found in the middle and an increase in those at either end of the wealth spectrum, creating a widening socio-economic gap in living standards. Alvaredo et al. (2017) also found that wealth inequalities grew in the first decade of the 2000s, with the top 1% increasing in wealth at a greater rate than those at the bottom (albeit with incomplete data).

### 4.2 Ethnicity change

Alongside polarisation, another pronounced pattern is the increase in classifications that are defined by the relatively high number of non-white ethnic residents. Between 1991 and 2011 there are increases in the Stretched Multi-Cultural Communities (C7) and Terraced Asian Communities (C9) classifications, with relatively large growth in the former. The largest contributor to the growth of Stretched Multi-Cultural Communities (C7) comes from Mixed Metropolitan (C1), where between 2001 and 2011 677 Mixed Metropolitan (C1) LSOAs changed to Stretched Multi-Cultural Communities (C7) (Table 10). The increase in Terraced Asian Communities (C9) predominately comes from Money Conscious Terraces (C4); between 2001 and 2011 a further 583 changed.

In both cases there appear to be elements of geographical focusing. Owen (2014) found an acceleration of immigration of Black African ethnicities to the UK over the previous 20 years, with much of this growth occurring within inner London. These results concur with those found within this study, with Stretched Multi-Cultural Communities (C7), which have a strong contingent of Black ethnic groups, tending to evolve from Mixed Metropolitan (C1) areas. The geographical focus can also be found in the growth of Terraced Asian Communities (C9), although to a lesser extent. Much of the growth here is from Money Conscious Terraces (C4) LSOAs. The key characteristics that these two classifications have in common are the high density of terraced housing located in traditional working-class areas. Pakistani, Indian and Bangladeshi ethnic groups can have extended multi-generation households. These groups have adapted the terraced house to the needs of these extended families, by building extensions and buying neighbouring houses (Shaw, 2004).

The changes from Mixed Metropolitan (C1) to Stretched Multi-Cultural Communities (C7) show increases in Black ethnic residents, unemployment levels, number of lone parent households, long-

term illness and those working part-time or not working to look after the family. The accommodation type remains static over the change, showing that this is not the reason or cause of the change and surprisingly the level of those not born in the UK also remains at a similar level. This could be due to Mixed Metropolitan (C1) being located within metropolitan areas, which tend to have a higher ethnic compositional mix than those in less urbanised environments. These characteristic changes hint that the change to Stretched Multi-Cultural Communities (C7) changes the key defining socio-economic aspects of the LSOA.

Widespread changes are identified by transitions from Money Conscious Terraces (C4) to Terraced Asian Communities (C9), although to a lesser extent. The differences found are primarily contained to these ethnic groups, with changes also in long-term illness, those working part-time and those staying home to look after the family. Characteristics that remain static include the accommodation types and the age profiles. The key factor here is housing type, which as pointed out previously may be a key driver in selecting an area to relocate.

The results suggest that there are demographic processes of selective migration or differences in natural change (births and deaths) occurring. Since accommodation type remains similar, the increases in non-White ethnicity are not necessarily a result of housing developments. The pull factor in these cases could be one of community, to be near those of a similar ethnicity, with areas providing appropriate goods and services. It could also be, in the case of Stretched Multi-Cultural Communities (C7), an attempt to find a new living or vocation. In addition, the similar age profiles before and after the classification change highlight that this is not necessarily a displacement of those already living there, but a changes of sufficient numbers (through migration and natural change) to result in the average characteristics and thus the classification, changing.

Large scale surveys have collected data on ethnicity alongside sociodemographic characteristics from well before the 1991 Census we use here which suggest that processes of change and a pulling apart have been operating over a longer time frame (Jivraj, 2020). Those who described their ethnicity as anything other than White British increased by 7% between the 2001 and 2011 Censuses, with the overall populations doubling since 1991 in England and Wales (Jivraj & Simpson, 2015). Black African ethnic groups grew faster than any other ethnic minority, with 100% growth between 2001 and 2011; Indian, Pakistan and Bangladeshi ethnic groups also grew relatively fast, with 34%, 55% and 56% growth respectively (Jivraj & Simpson, 2015). The changes in our classification are more accentuated between 2001 and 2011 than between 1991 and 2001. This could potentially be a result of external events, such as the Economic Recession of 2008 and immigration from EU A8 accession states to England and Wales in mid-decade. Catney (2017) also found an increasing geographic spread

of ethnic diversity between 2001 and 2011 and this is projected to continue over the next few decades (Lomax et al., 2020).

### 4.3 Inner City Change

Another area of concentrated change are the classifications within metropolitan and inner-city areas. LSOAs assigned the classifications Mixed Metropolitan (C1) and Student Sprawl (2), who live near the centre of urban areas for easy access to work or for study (Vickers, 2010), have grown in both census years, 2001 and 2011. The increasing number of Student Sprawl (2) is in line with the growth in popularity and availability of higher education (Smith, 2009). Juxtaposed to this is Endeavouring Young Urban Renters (C10) also found in urban areas and appear to be young professionals, who see a decrease in the count of LSOAs. That being said, the biggest contributor of the increase in Mixed Metropolitan (C1) comes from Endeavouring Young Urban Renters (C10), with 210 LSOAs changing between 1991 and 2001, increasing to 611 between 2001 and 2011. This can, therefore, be seen as an expansion of heavily urbanised and metropolitan areas.

Student Sprawl (C2) proportionally increases dramatically, however, the absolute number of LSOAs changing are small. Student Sprawl (C2) gains from all other classification, both between 1991 to 2001 and 2001 to 2011. Rugg et al. (2002) found that students adapt to pretty much any housing type, as long as they are able to accommodate two or more residents and commonly, are furnished. Smith (2009) explains that there had been, up to that point, relatively little study on the socio-economic impacts of student migration and influxes and little attention paid by government agencies. Consequently, there have been relatively few strategic developments aimed directly at providing housing and services to students, although this appears to be changing since the late 2000s. This has potentially influenced the less focused migration of students found in this study, however, the coding changes that student populations have went through in 2001, may have diluted the results found; students are now counted at the home address rather than their term time address (Shuttleworth & Lloyd, 2009). Comprehensive studies involving student migrations are limited, primarily due to the dearth of accurate data (Smith, 2009).

There is a small peak in changes from Money Conscious Terraces (C4) to Student Sprawl (C2), with 71 between 1991 and 2001 and 111 between 2001 and 2011. In terms of the characteristics of these classifications, there are few similarities between the two. The main similarities are found in the housing stock: both classifications tend to have low number of detached and semi-detached housing, a focus on terraced housing, although the Student Sprawl (C2) does have a higher proliferation of flats. The differences are focused around the student populations and the increased ethnicity they brought. The results support the theory that in these areas, the students are displacing the previous residents, or

at least, are having such an impact as to change the average classification for the area. Therefore, few socio-economic characteristics appear to be increased in these cases.

The classifications Endeavouring Young Urban Renters (C10) and Mixed Metropolitan (C1) share a number of similar characteristics. The most prevalent accommodation type are flats, with a tendency to private rent and a relatively high number of ethnic groups are found within these areas. These similarities are understandable as both classifications are found around metropolitan centres. While much of the housing stock has stayed similar, there is a decrease in the prevalence of terraced housing and an increase in the number of flats. In addition, the age profiles of the areas differ, with Mixed Metropolitan (C1) being more orientated towards younger populations and students. These differences indicate that these changes may be a result of some redevelopment, with terraced housing being replaced by flats, or more flats being made available, with younger aged residents moving in.

## 5 Conclusion

The primary aim of this study was to develop a general purpose geodemographic classification which captures socio-demographic changes in neighbourhoods over time and then to use this classification to investigate changes in socio-economic characteristics at a neighbourhood level, defined by LSOAs, over time. Through the comparison of the assignment to groups at different time points it can be seen that most neighbourhoods have not changed over time, with the majority of those that do being located in urban areas. The rate of change appears to be slow which raises questions about the ability of shorter cycle regeneration projects to change the core characteristics of areas. That being said, there are a number of neighbourhoods which do change classification and these can be themed as:

- Socio-economic polarisation, characterised by a decrease in neighbourhoods found in the middle of the socio-economic spectrum, with an increase in number of those at either end;
- Growth in the number of neighbourhoods with non-White ethnic residents, mainly Black ethnic minorities and Asian based communities with growth appearing to be geographically focused;
- A reorganisation and increase in the classifications defining central urban areas, signalling development or growth of metropolitan areas.

A secondary aim was to compare the characteristics of the areas that change and to assess whether any characteristics could be classed as ingrained within the area. Broadly, when looking across the most common classification changes, many characteristics remain stable. In areas that are characterised by polarisation many of the key defining characteristics can be regarded as ingrained. However, these characteristics may have been enhanced, resulting in a change in the socio-economic profile. Speculatively, the change of classifications in these examples was a result of their resilience to external events, such as the Economic Recession, or levels of development and investment. The

changes found within metropolitan areas also supports the idea that core characteristics do no change much, with many of the key defining features staying at similar levels, although they have changed enough to warrant a classification change. On the other hand, it appears that increases in ethnicity, due to both immigration and subnational moves, results in more wholescale social changes, even though the physical characteristics (such as the nature of the housing stock) remain static.

Finally, a third aim was to assess the ability of geodemographics to capture socio-economic changes in neighbourhoods over time. The results found here show that geodemographics can be used to evaluate change, although the quality of the analysis will be dependent on the choices of input data, the clustering method and the decisions made during the clustering process. A limiting reason for not using geodemographics as a comparative tool is that the data used may not be directly comparable over time and that the geographic units often change. However, if care is taken over selecting and grouping the data so it is comparable, and the data are converted to a common set of geographic boundaries, then geodemographics can be used as a dynamic descriptive tool. A drawback, as with any categorisation of an underlying distribution, is that a seemingly large change in local characteristics may not be sufficient for the clustering to lead to a different membership being assigned or conversely, a seemingly small change may lead to an area being assigned to a different cluster. There may be merit in attempting similar work with the time-series of inputs used in one principal components analysis. A potential source for time and geographic consistent inputs is the gridded data from 'PopChange' (see Lloyd et al., 2017a and used in Lloyd et al., 2017b and Mohan et al., 2020). Exeter et al. (2019) also demonstrate how attributes about area populations can be grouped into common trajectories over time.

The results provided here will allow national and local government officers to assess the impact of policy interventions and investments and enable the comparison of different types of actions. If the changes found here could be compared to the policy interventions, then context for the changes could be gained. The analysis can be taken a step further, by not just determining if an area has increased or decreased in social standing, but also looking into the contributing characteristic changes. This is the benefit of geodemographic classifications over single value indexes. For instance, assessing the impacts of certain characteristics, such as unemployment, social renting or change by ethnic group. This can lead to the targeting of goods and services relative to the changes that are occurring locally.

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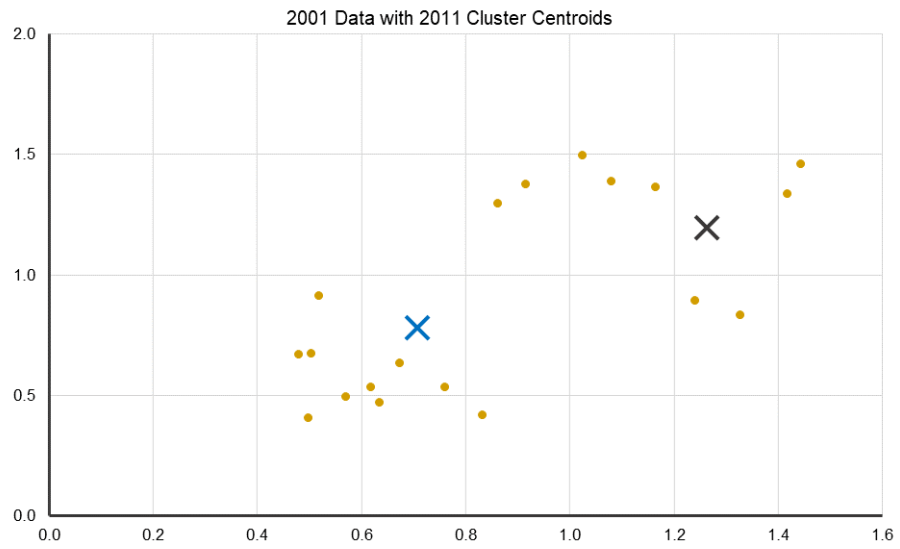
**Figure 1: Assigning clusters across years (hypothetical data)**

Cluster centroids from the 2011 classification are input into the k-means algorithm as cluster seeds for the 2001 data




2001 data points are assigned to the closest 2011 centroid

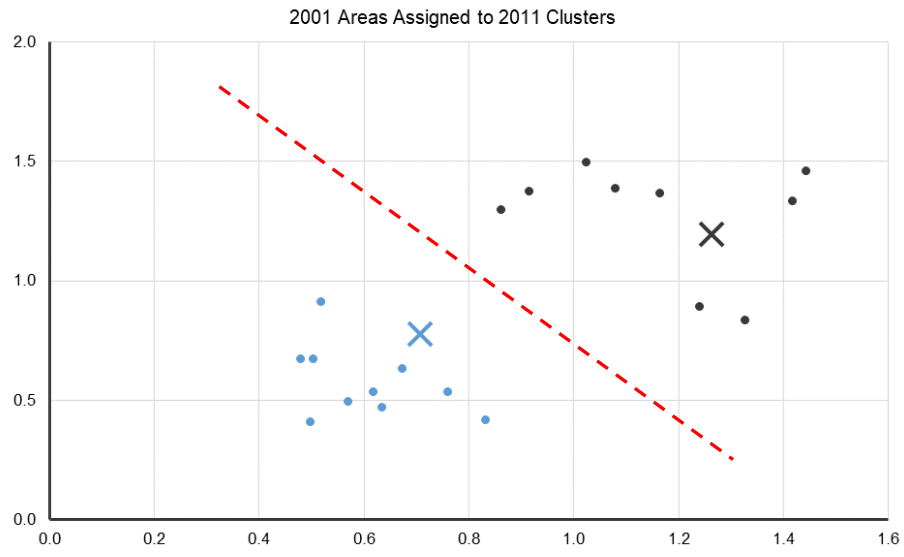
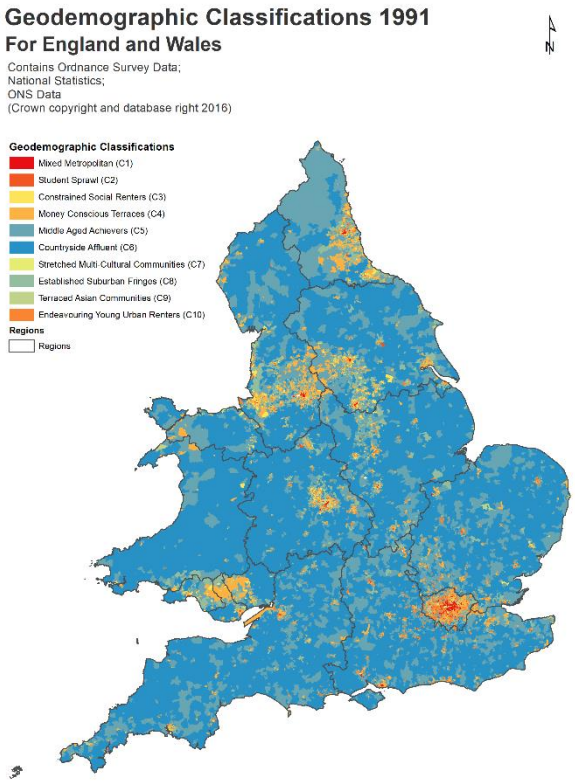
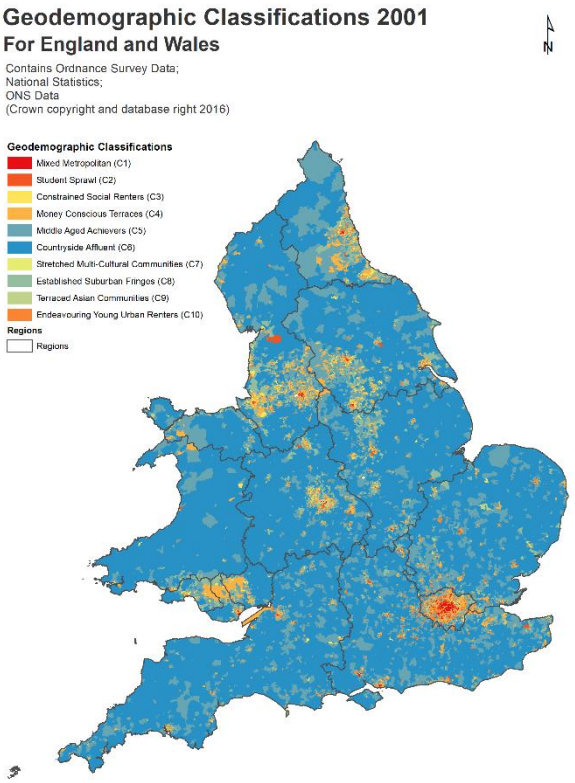


**Figure 2: Comparable geodemographic classification: England & Wales 1991, 2001, 2011**

1991 Classification




2001 Classification




2011 Classification

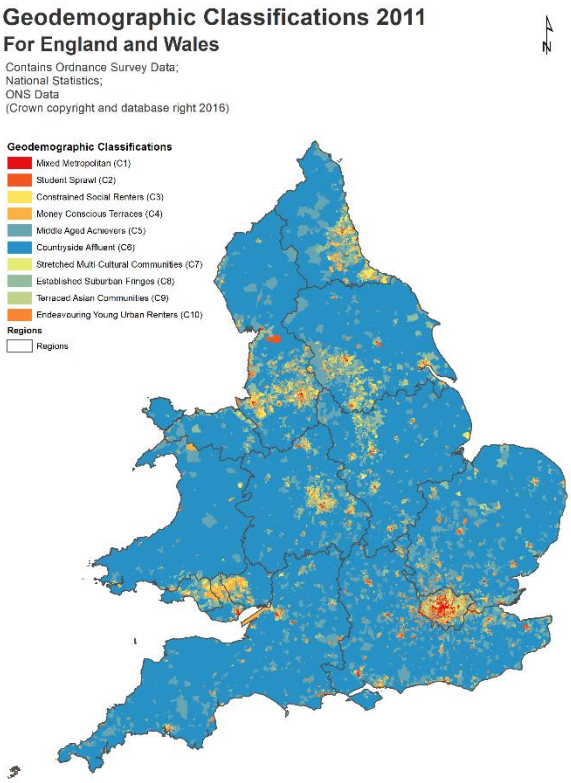
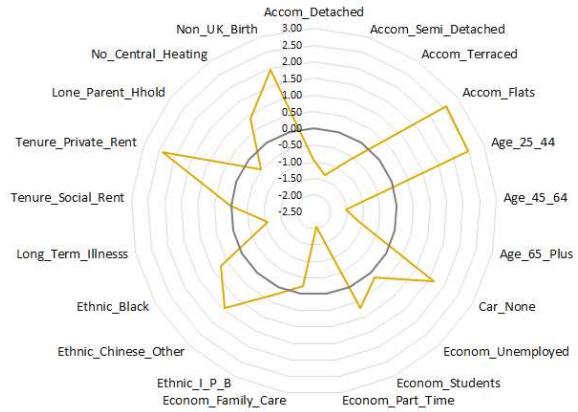
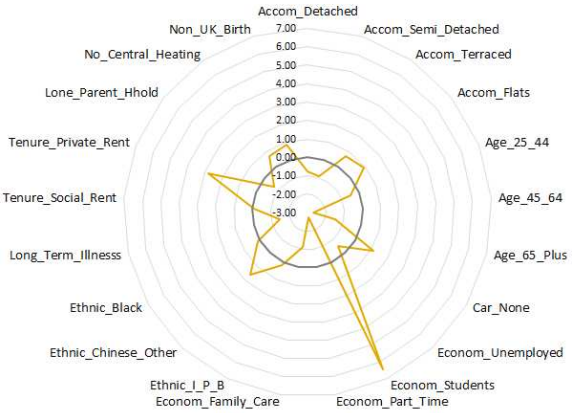

Geodemographic Classifications 2011
For England and Wales
Contains Ordnance Survey Data;
National Statistics;
ONS Data
(Crown copyright and database right 2016)
N
Geodemographic Classifications
Mixed Metropolitan (C1)
Student Sprawl (C2)
Constrained Social Renters (C3)
Money Conscious Terraces (C4)
Middle Aged Achievers (C5)
Countryside Affluent (C6)
Stretched Multi-Cultural Communities (C7)
Established Suburban Fringes (C8)
Terraced Asian Communities (C9)
Endeavouring Young Urban Renters (C10)
Regions
Regions

**Figure 3a: Cluster variable characteristics for groups 1 to 5**

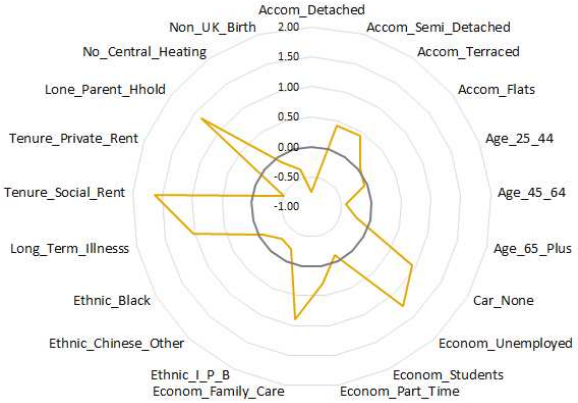
Mixed Metropolitan



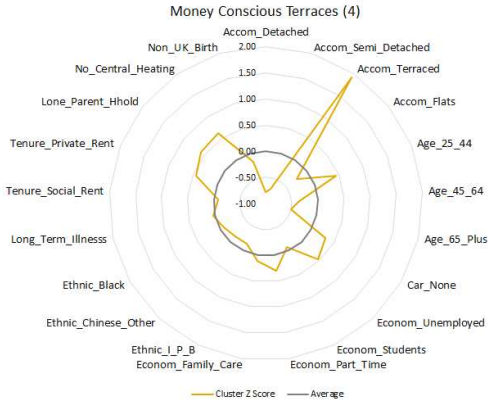

Student Sprawl




Constrained Social Renters




Money Conscious Terraces




Middle Aged Achievers

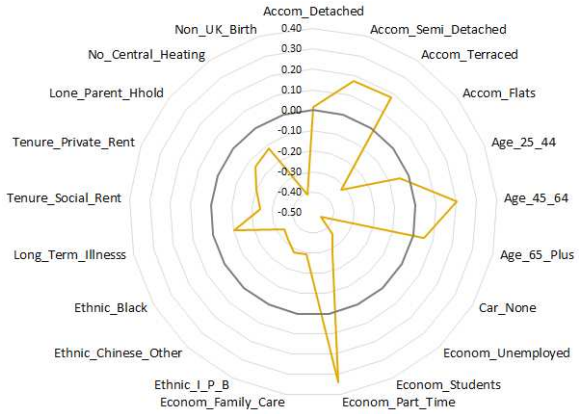
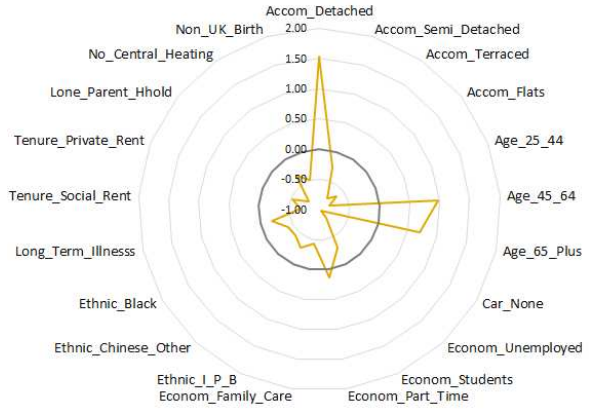
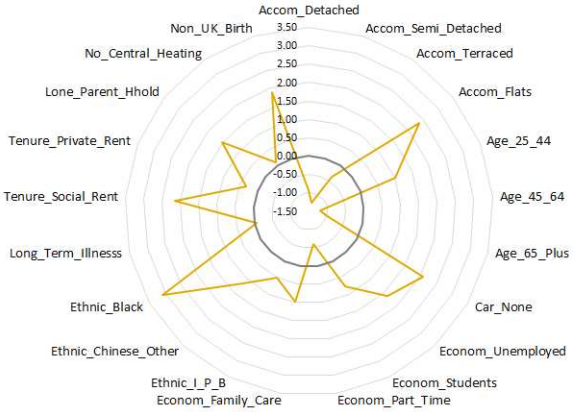


**Figure 3b: Cluster variable characteristics for groups 6 to 10**

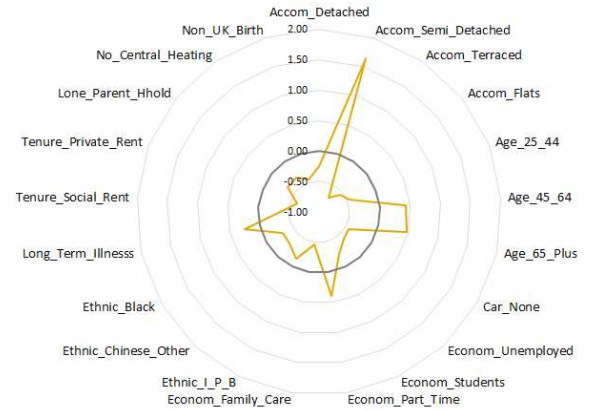
Countryside Affluent



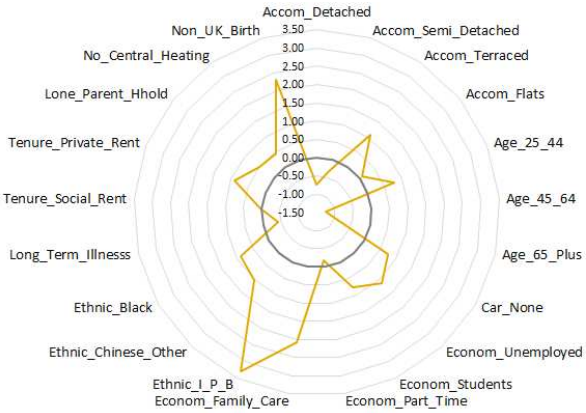

Stretched Multi-Cultural Communities




Established Suburban Fringes




Terraced Asian Communities




Endeavouring Young Urban Renters

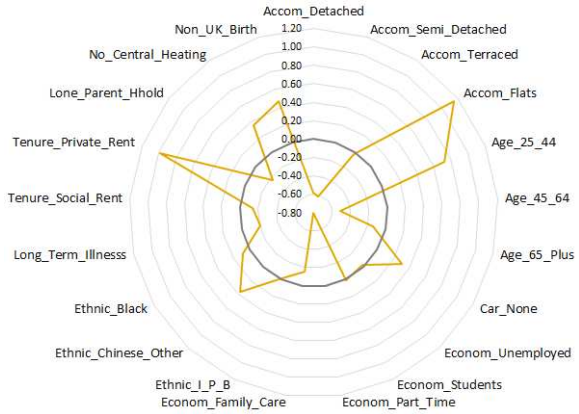
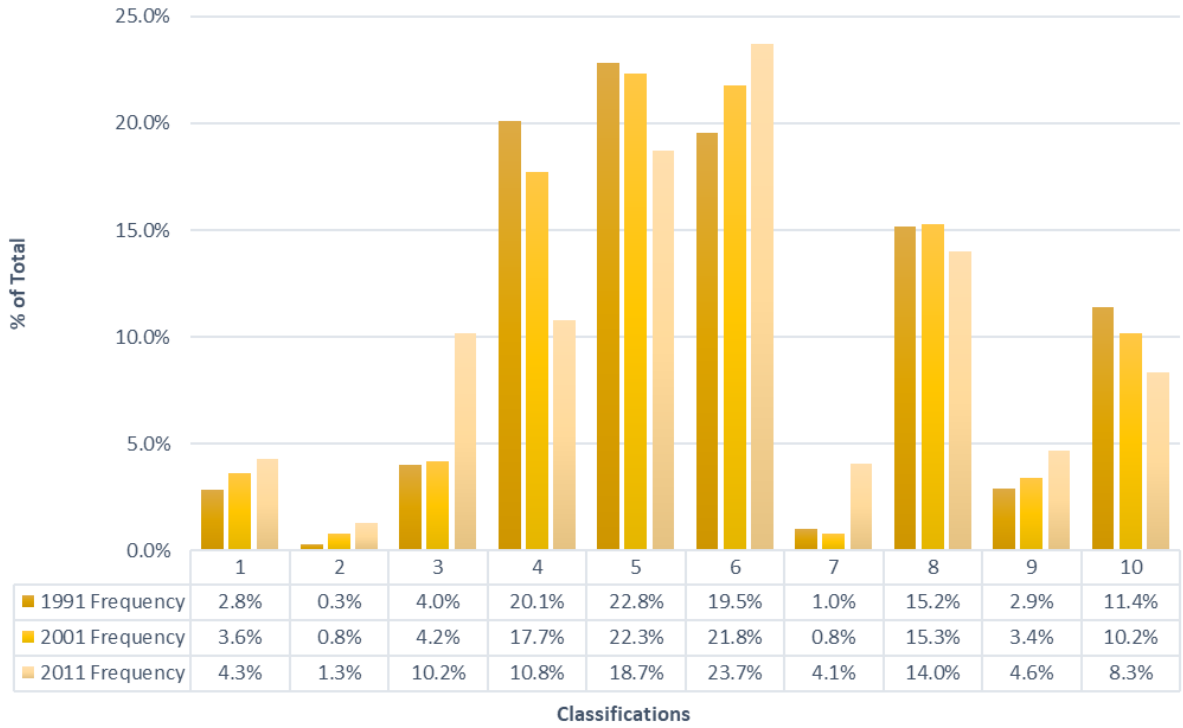


**Figure 4: Proportion of LSOAs in each cluster in each year 1991, 2001 and 2011**




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1991 Frequency | 2.8% | 0.3% | 4.0% | 20.1% | 22.8% | 19.5% | 1.0% | 15.2% | 2.9% | 11.4% |
| 2001 Frequency | 3.6% | 0.8% | 4.2% | 17.7% | 22.3% | 21.8% | 0.8% | 15.3% | 3.4% | 10.2% |
| 2011 Frequency | 4.3% | 1.3% | 10.2% | 10.8% | 18.7% | 23.7% | 4.1% | 14.0% | 4.6% | 8.3% |

Note: 1 Mixed Metropolitan; 2 Student Sprawl; 3 Constrained Social Renters; 4 Money Conscious Terraces; 5 Middle Aged Achievers; 6 Countryside Affluent; 7 Stretched Multi-Cultural Communities; 8 Established Suburban Fringes; 9 Terraced Asian Communities; 10 Endeavouring Young Urban Renters.

**Table 1: Variables from 1991, 2001 and 2011 included in the time comparable geodemographic classification**

| Theme | Variable Description | Variable Label |
|---|---|---|
| Age-structure | % Aged 25 to 44 | Age_25_44 |
| | % Aged 45 to 64 | Age_45_64 |
| | % Aged 65+ | Age_65_Plus |
| Socio-economic | % Unemployed | Econom_Unemployed |
| | % Students | Econom_Students |
| | % Part time workers | Econom_Part_Time |
| | % Caring for family full time | Econom_Family_Care |
| | % No access to a vehicle | Car_None |
| | % Access to two more vehicles | Car_Two_Plus |
| | % Long term illness | Long_Term_Illnesss |
| Cultural | % Indian, Pakistani & Bangladeshi ethnicity | Ethnic_I_P_B |
| | % Chinese ethnicity | Ethnic_Chinese_Other |
| | % Black ethnicity | Ethnic_Black |
| | % Not born within the UK | Non_UK_Birth |
| Household | % Private renting | Tenure_Private_Rent |
| | % Lone parent households | Lone_Parent_Hhold |
| | % No central heating | No_Central_Heating |
| Housing | % Detatched accomodation | Accom_Detached |
| | % Semi detached accomodation | Accom_Semi_Detached |
| | % Terraced accomodation | Accom_Terraced |
| | % Flat accomodation | Accom_Flats |

**Table 2: Clusters ranked by measures to aid selection of 'k'**

| K groups | Variance | Range | Average Distance to Centroid | 1/4 Less than average membership | Sum of Rank | Rank (Sum of Ranks) |
|---|---|---|---|---|---|---|
| 2 | 26 | 18 | 29 | 1 | 74 | 23 |
| 3 | 28 | 27 | 28 | 1 | 84 | 28 |
| 4 | 29 | 29 | 27 | 1 | 86 | 29 |
| 5 | 27 | 28 | 26 | 1 | 82 | 27 |
| 6 | 24 | 24 | 25 | 1 | 74 | 23 |
| 7 | 25 | 26 | 24 | 6 | 81 | 26 |
| 8 | 23 | 25 | 23 | 6 | 77 | 25 |
| 9 | 22 | 23 | 22 | 6 | 73 | 22 |
| **10** | **19** | **20** | **19** | **6** | **64** | **18** |
| 11 | 21 | 22 | 21 | 6 | 70 | 21 |
| 12 | 20 | 21 | 20 | 6 | 67 | 19 |
| **13** | **17** | **17** | **18** | **6** | **58** | **15** |
| 14 | 18 | 19 | 17 | 15 | 69 | 20 |
| 15 | 16 | 16 | 16 | 6 | 54 | 12 |
| 16 | 13 | 15 | 15 | 15 | 58 | 15 |
| 17 | 14 | 14 | 14 | 15 | 57 | 14 |
| 18 | 11 | 11 | 12 | 15 | 49 | 11 |
| 19 | 15 | 12 | 13 | 19 | 59 | 17 |
| 20 | 12 | 13 | 11 | 19 | 55 | 13 |
| **21** | **9** | **7** | **9** | **6** | **31** | **3** |
| 22 | 10 | 6 | 10 | 19 | 45 | 9 |
| 23 | 7 | 3 | 8 | 19 | 37 | 5 |
| 24 | 8 | 1 | 7 | 19 | 35 | 4 |
| 25 | 6 | 8 | 6 | 25 | 45 | 9 |
| 26 | 4 | 9 | 5 | 25 | 43 | 7 |
| 27 | 2 | 4 | 3 | 19 | 28 | 1 |
| 28 | 5 | 10 | 4 | 25 | 44 | 8 |
| 29 | 1 | 2 | 1 | 25 | 29 | 2 |
| 30 | 3 | 5 | 2 | 29 | 39 | 6 |

**Table 3: Stability and change in LSOA cluster assignment**

| 2011 to 2001 | Count of LSOAs | % of Total |
|---|---|---|
| Total | 34,747 | 100.00% |
| Same cluster | 25,702 | 73.97% |
| Change of cluster | 9,045 | 26.03% |
| | | % of Change |
| Rural areas | 697 | 7.70% |
| Urban areas | 8,348 | 92.29% |

| 2011 to 1991 | Count of LSOAs | % of Total |
|---|---|---|
| Total | 34,747 | 100.00% |
| Total Same | 22,752 | 65.48% |
| Total Change | 11,995 | 34.52% |
| | | % of Change |
| Rural areas | 1,307 | 10.90% |
| Urban areas | 10,688 | 89.10% |

| 2001 to 1991 | Count of LSOAs | % of Total |
|---|---|---|
| Total | 34,747 | 100.00% |
| Total Same | 28,379 | 81.67% |
| Total Change | 6,368 | 18.33% |
| | | % of Change |
| Rural areas | 750 | 11.80% |
| Urban areas | 5,618 | 88.22% |

**Table 4: Absolute changes between clusters**

1991 Clusters

| 2001 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 823 | 2 | 16 | 26 | 1 | 1 | 152 | 0 | 21 | 210 | 1252 |
| 2 | 26 | 91 | 39 | 71 | 13 | 5 | 13 | 3 | 5 | 10 | 276 |
| 3 | 2 | 0 | 1038 | 270 | 17 | 0 | 18 | 29 | 25 | 51 | 1450 |
| 4 | 2 | 1 | 91 | 5487 | 117 | 6 | 3 | 9 | 229 | 210 | 6155 |
| 5 | 1 | 0 | 97 | 588 | 6160 | 300 | 0 | 358 | 46 | 202 | 7752 |
| 6 | 0 | 0 | 2 | 18 | 956 | 6367 | 0 | 223 | 1 | 4 | 7571 |
| 7 | 55 | 2 | 9 | 36 | 1 | 0 | 111 | 0 | 19 | 34 | 267 |
| 8 | 1 | 0 | 8 | 12 | 528 | 83 | 0 | 4599 | 30 | 53 | 5314 |
| 9 | 11 | 2 | 44 | 355 | 37 | 1 | 12 | 30 | 601 | 79 | 1172 |
| 10 | 65 | 3 | 39 | 121 | 99 | 22 | 33 | 25 | 29 | 3102 | 3538 |
| Total | 986 | 101 | 1383 | 6984 | 7929 | 6785 | 342 | 5276 | 1006 | 3955 | 34747 |

2001 Clusters

| 2001 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 552 | 22 | 93 | 90 | 3 | 1 | 75 | 0 | 37 | 611 | 1484 |
| 2 | 8 | 232 | 21 | 111 | 15 | 2 | 2 | 9 | 11 | 32 | 443 |
| 3 | 2 | 1 | 1069 | 839 | 505 | 6 | 5 | 443 | 172 | 493 | 3535 |
| 4 | 1 | 1 | 14 | 3651 | 14 | 2 | 1 | 9 | 44 | 12 | 3749 |
| 5 | 1 | 1 | 16 | 392 | 5646 | 133 | 0 | 176 | 39 | 93 | 6497 |
| 6 | 1 | 0 | 2 | 0 | 755 | 7388 | 0 | 97 | 0 | 2 | 8245 |
| 7 | 677 | 10 | 11 | 54 | 2 | 0 | 176 | 0 | 77 | 412 | 1419 |
| 8 | 0 | 0 | 37 | 1 | 355 | 6 | 0 | 4452 | 5 | 6 | 4862 |
| 9 | 3 | 2 | 18 | 583 | 59 | 3 | 4 | 90 | 756 | 97 | 1615 |
| 10 | 7 | 7 | 169 | 434 | 398 | 30 | 4 | 38 | 31 | 1780 | 2898 |
| Total | 1252 | 276 | 1450 | 6155 | 7752 | 7571 | 267 | 5314 | 1172 | 3538 | 34747 |

1991 Clusters

| 2001 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 318 | 9 | 89 | 95 | 2 | 2 | 175 | 0 | 57 | 737 | 1484 |
| 2 | 20 | 84 | 59 | 180 | 23 | 7 | 17 | 6 | 11 | 36 | 443 |
| 3 | 19 | 0 | 850 | 1130 | 331 | 7 | 5 | 453 | 89 | 651 | 3535 |
| 4 | 1 | 1 | 17 | 3596 | 60 | 3 | 0 | 14 | 40 | 17 | 3749 |
| 5 | 2 | 0 | 87 | 779 | 4889 | 267 | 0 | 341 | 30 | 102 | 6497 |
| 6 | 0 | 0 | 2 | 24 | 1542 | 6372 | 0 | 303 | 0 | 2 | 8245 |
| 7 | 616 | 6 | 10 | 101 | 2 | 0 | 136 | 0 | 61 | 487 | 1419 |
| 8 | 0 | 0 | 54 | 10 | 672 | 70 | 0 | 4027 | 12 | 17 | 4862 |
| 9 | 1 | 1 | 44 | 654 | 37 | 1 | 5 | 82 | 682 | 108 | 1615 |
| 10 | 9 | 0 | 171 | 415 | 371 | 56 | 4 | 50 | 24 | 1798 | 2898 |
| Total | 986 | 101 | 1383 | 6984 | 7929 | 6785 | 342 | 5276 | 1006 | 3955 | 34747 |

Note: 1 Mixed Metropolitan; 2 Student Sprawl; 3 Constrained Social Renters; 4 Money Conscious Terraces; 5 Middle Aged Achievers; 6 Countryside Affluent; 7 Stretched Multi-Cultural Communities; 8 Established Suburban Fringes; 9 Terraced Asian Communities; 10 Endeavouring Young Urban Renters.

**Table 4: Net changes between clusters**

1991 Clusters

| 2001 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Changes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 24 | -14 | -24 | 0 | -1 | -97 | 1 | -10 | -145 | -266 |
| 2 | -24 | 0 | -39 | -70 | -13 | -5 | -11 | -3 | -3 | -7 | -175 |
| 3 | 14 | 39 | 0 | -179 | 80 | 2 | -9 | -17 | 19 | -12 | -63 |
| 4 | 24 | 70 | 179 | 0 | **471** | 12 | 33 | 3 | 126 | -89 | 829 |
| 5 | 0 | 13 | -80 | **-471** | 0 | **656** | 1 | 170 | -9 | **-103** | 177 |
| 6 | 1 | 5 | -2 | -12 | **-656** | 0 | 0 | -140 | 0 | 18 | -786 |
| 7 | 97 | 11 | 9 | -33 | -1 | 0 | 0 | 0 | -7 | -1 | 75 |
| 8 | -1 | 3 | 17 | -3 | -170 | 140 | 0 | 0 | 0 | -28 | -42 |
| 9 | 10 | 3 | -19 | -126 | 9 | 0 | 7 | 0 | 0 | -50 | -166 |
| 10 | 145 | 7 | 12 | 89 | **103** | -18 | 1 | 28 | 50 | 0 | 417 |
| Changes | 266 | 175 | 63 | -829 | -177 | 786 | -75 | 42 | 166 | -417 | |

2001 Clusters

| 2011 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Changes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | -14 | -91 | -89 | -2 | 0 | **602** | 0 | -34 | **-604** | -232 |
| 2 | 14 | 0 | -20 | -110 | -14 | -2 | 8 | -9 | -9 | -25 | -167 |
| 3 | 91 | 20 | 0 | **-825** | **-489** | -4 | 6 | **-442** | -154 | **-324** | -2121 |
| 4 | 89 | 110 | **825** | 0 | 378 | -2 | 53 | -8 | **539** | **422** | 2406 |
| 5 | 2 | 14 | **489** | -378 | 0 | **622** | 2 | 179 | 20 | 305 | 1255 |
| 6 | 0 | 2 | 4 | 2 | **-622** | 0 | 0 | -91 | 3 | 28 | -674 |
| 7 | -602 | -8 | -6 | -53 | -2 | 0 | 0 | 0 | -73 | -408 | -1152 |
| 8 | 0 | 9 | **442** | 8 | -179 | 91 | 0 | 0 | 85 | 32 | 488 |
| 9 | 34 | 9 | 154 | **-539** | -20 | -3 | 73 | -85 | 0 | -66 | -443 |
| 10 | **604** | 25 | **324** | **-422** | -305 | -28 | **408** | -32 | 66 | 0 | 640 |
| Changes | 232 | 167 | 2121 | -2406 | -1255 | 674 | 1152 | -488 | 443 | -640 | |

1991 Clusters

| 2011 Clusters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Changes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 11 | -70 | -94 | 0 | -2 | **441** | 0 | -56 | **-728** | -498 |
| 2 | -11 | 0 | -59 | -179 | -23 | -7 | -11 | -6 | -10 | -36 | -342 |
| 3 | 70 | 59 | 0 | **-1113** | -244 | -5 | 5 | -443 | -45 | **-480** | -2196 |
| 4 | 94 | 179 | **1113** | 0 | **719** | 21 | 101 | -4 | **614** | 398 | 3235 |
| 5 | 0 | 23 | 244 | **-719** | 0 | **1275** | 2 | 331 | 7 | 269 | 1432 |
| 6 | 2 | 7 | 5 | -21 | -1275 | 0 | 0 | -233 | 1 | 54 | -1460 |
| 7 | -441 | 11 | -5 | -101 | -2 | 0 | 0 | 0 | -56 | **-483** | -1077 |
| 8 | 0 | 6 | **443** | 4 | -331 | 233 | 0 | 0 | 70 | 33 | 458 |
| 9 | 56 | 10 | 45 | **-614** | -7 | -1 | 56 | -70 | 0 | -84 | -609 |
| 10 | **728** | 36 | **480** | 398 | 269 | 54 | **483** | 33 | 84 | 0 | 1057 |
| Changes | 498 | 342 | 2196 | -3235 | -1432 | 1460 | 1077 | -458 | 609 | -1057 | |

Note: 1 Mixed Metropolitan; 2 Student Sprawl; 3 Constrained Social Renters; 4 Money Conscious Terraces; 5 Middle Aged Achievers; 6 Countryside Affluent; 7 Stretched Multi-Cultural Communities; 8 Established Suburban Fringes; 9 Terraced Asian Communities; 10 Endeavouring Young Urban Renters.