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Beyond the Strictly Orthodox / Mainstream Divide: Applying Geodemographic Analysis to a Small Nationwide Sub-Population

Abstract

The use of geodemographic analysis has a long history, arguably stretching back to Charles Booth's *Descriptive Map of London's Poverty,* produced in 1886 and the published classification of areas has invariably been based on all residents. The work described in this paper, however, is novel in the use of geodemographic analysis to focus on a single minority group within a national census. This paper describes the development of a methodology which allows geodemographic analysis to be applied to unevenly distributed minority sub-populations, overcoming two particular issues: finding a suitable geographic base to ensure data reliability; and developing a methodology to avoid known weaknesses in certain clustering techniques, specifically distortion caused by outlier cases and generation of sub-optimal local minimum solutions. The approach, which includes a visual element to final classification selection, has then been applied to establish the degree to which the Jewish population in an area is similar in character to, or differs from, Jews living in other areas of England and Wales, using data from the 2011 census. That group has been selected because of the maturity of its presence in Britain – study of this group may point the way for examination of other, more recently arrived, sub-populations. Previous studies have generally assumed homogeneity amongst 'mainstream' Jews and have not considered spatial variation, separating out only strictly orthodox enclaves. This paper demonstrates that there are indeed distinct socio-economic and demographic differences between Jewish groups in different areas, not fully attributable to the underlying mainstream social geography, whilst also identifying a strong degree of spatial clustering; it also establishes the practicality of applying geodemographic analysis to minority groups.

Keywords: geodemographic, census, cluster analysis, Jewish, England and Wales, minorities

1 Introduction

A range of techniques with the aim of subdividing a set of objects into a series of broadly homogenous sub-groups falls under the generic title of 'cluster analysis', sometimes referred to more formally as 'numerical taxonomy' (Lorr, 1983; Everitt et al, 2011). The addition of a spatial element to the analysis differentiates geodemographics from other forms of cluster analysis, and determines whether there is any locational relationship between similarly classified areas. Put perhaps too simply, geodemographics is the 'analysis of people by where they live' (Sleight, 1997, p16).

Geodemographic analysis has an extended history (Batey and Brown, 1995; Singleton, 2004; Singleton and Spielman, 2014) and some geodemographic investigations have included a religion or ethnicity variable in studies of the whole population, such as the study on ethnicity and school choice in Birmingham (Harris, Johnston, and Burgess, 2007). However, the work described in this paper is unusual in the use geodemographic analysis to classify areas solely on the basis of the characteristics of a single minority group (Jews) within a national census.

So, what is the wider benefit of this research? As with any form of neighbourhood classification, the outputs can be used to identify the needs of the targeted group (for example, assessing future social and community requirements), and previous work in examining socio-economic/demographic issues for Jews in England and Wales has only been able to make use of geographically limited surveys (for example, Kosmin and Levy, 1981), or small sample national studies (Graham, Staetsky, and Boyd, 2014; also Kotler-Berkowitz, 2006, and Goldstein, 2013 for equivalent American experience). The approach adopted here could be applied to other sub-populations, so why select the Jewish group for this study? The majority of Jews in the UK have their roots in the major migration westwards from the Russian Empire which took place between 1880 and 1914; some chose the UK as their preferred destination, others had hoped or intended to continue on to the USA, but either could not face or afford the second stage of the journey (Endelman, 2002). During the first half of the twentieth century, Jews formed the only significant non-western-European and non-Christian minority group in Britain. Immigration from a range of world regions during the second half of the century now means that Britain is home to overseas and first and second generation UK-born citizens with a range of ethnic group and religious

backgrounds (Simpson, 2012). However, the majority of Jews in Britain are now third to fifth generation UK born; so a study focused on this well-established group may provide pointers for other groups whose UK presence is less mature (Waterman and Kosmin, 1987).

Previous studies have identified concentrations of strictly orthodox Jews (Vulkan and Graham, 2008; Graham, 2013 in the UK; and Comenetz, 2006 in the USA) and have considered their socio-economic characteristics finding large family sizes and high levels of deprivation (Holman and Holman, 2002; Valins, 2003). Other studies have given some limited attention to spatial variation in the characteristics of 'mainstream' Jews (Abramson et al, 2011; Becher et al, 2002; Graham et al, 2014); in most studies, however, this group, whose overall characteristics (as measured by the census) are not dissimilar to the wider UK population, tend to be considered as a homogenous group. This paper develops a methodology to overcome the challenges in applying geodemographic analysis to unevenly distributed minority groups, and applies that approach to establish the degree to which the Jewish population in one area is similar to or differs from Jews living in other areas.

2 Classification Techniques and Previous Census Analyses

The data on which clustering techniques are to be applied can usually be presented as an N row by k column matrix, where each row represents a case or entity, and each column represents one of the characteristics or variables of the cases. The background to and overall process undertaken in cluster analysis and geodemographics are now well established and do not need to be detailed here. Both Lorr (1983) and Everitt et al (2011) provide comprehensive overviews of the clustering concept; Harris, Sleight, and Webber (2005) provide a briefer synopsis. They note that there are two basic 'families' of clustering techniques: hierarchical (where cases are progressively grouped into clusters) and optimising techniques, which generally commence by subdividing the totality of entities into a number of clusters and then iteratively attempt to improve the clustering by moving the boundaries between clusters.

Analyses based on USA, UK, and other census data (usually in combination with other information) have been carried out by commercial organisations for use primarily as a tool to target marketing campaigns for private-sector organisations (Webber, 1985; Singleton and Spielman, 2014, Harris, Sleight, and Webber, 2005).

Non-commercial analyses of UK census data have been carried out for, or in partnership with, the Office for National Statistics (ONS) from the 1981 census onwards. Local authority level analyses are described by Wallace and Denham (1996), and Vickers, Rees, and Birkin (2003); and analyses based on lower level geographies by Charlton, Openshaw, and Wymer (1985), Blake and Openshaw (1995), and Vickers, Rees, and Birkin (2005). Despite extensive experimentation, in each case the final analyses were produced through the use of Ward's hierarchical approach, or the *k*-means algorithm, or various combinations of the two (see Lorr, 1983, and Everitt et al, 2011, for the detail of these techniques). A multi-level *k*-means assessment was adopted by ONS in carrying out a classification based on the 2011 census (ONS, 2014).

3 Technical Challenges

So, what lessons can be learned from previous work in this field? In terms of the techniques, hierarchical methods benefit from a greater transparency in the process and the sequential formation of clusters, but are 'sensitive to outliers' (Everitt et al, 2011, p79; see also Hubert, 1974). In addition, the movement of cluster centres which occurs as clusters are merged can mean that cases close to the periphery of a cluster might be located closer to the centre of a different later-stage cluster – as 'making the best decision at each particular step does not necessarily lead to an optimal overall result' (Harris, Sleight, and Webber, 2005, p162). Of the hierarchical techniques, Ward's algorithm is the most popular for assessing population census data.

Conversely, the *k*-means approach has the benefit of ensuring that the solution produced does locate every case in the cluster to which it is 'closest'. However, it is something of a 'black box' approach and is highly prone to produce local minimum solutions; as Everitt et al (2011) indicate, a 100 case, 5 cluster scheme has over 10^{67} possible solutions, and they cannot realistically all be tested. Steinley (2003, 2006) recommends running large *k*-means clustering analyses with at least 5000 different starting points in order to overcome the issue of local minima.

The approach adopted in this paper seeks combine positive elements of both techniques. Whilst combined technique approaches have been used in earlier census-based classifications (Bailey et al, 2000; ONS, 2003), those assessments used the *k*-means technique solely to re-allocate Ward's algorithm cases to their nearest cluster

centre. The approach adopted in the current paper is novel in combining two techniques specifically to address the local minima and outlier issues.

4 Development of the Study Classification Methodology

Prior to carrying out the main assessment which is described in detail in later sections, some extensive preliminary analysis was carried out, using 2011 England and Wales census data for Jewish residents aggregated at local authority level. That analysis confirmed the instability of the *k*-means approach with a variety of solutions (local minima) being produced. It also confirmed that the inclusion or exclusion of outlier cases produced different results over a wide range of number of clusters when using Ward's method, and also using the *k*-means technique.

Bearing in mind everything which has been identified and discussed so far, a hybrid classification approach has been devised, based around:

1 Identifying cases where the closest neighbour distance can be regarded as an outlier.

2 Using Ward's approach to cluster the (non-outlier) cases.

3 Running a *k*-means clustering on the dataset without outliers, using the Ward cluster centres as a starting point, to re-allocate cases to their nearest cluster, and produce final cluster centres.

4 Adding the outliers back into the dataset and, using the final cluster centres, allocating the outliers to classes.

5 Mapping the results and finalising the number of classes to be used.

The methodology avoids using the *k*-means approach with a random starting point – so the issues surrounding the optimisation process do not arise. Similarly, the issue of outliers is taken out of the process; their re-incorporation at the end ensures that all cases can be involved, but outliers do not influence the position of class centres. A preliminary choice of the range of number of clusters can be made early in the process, but this can be revised, and the final choice is left to the qualitative judgement of the researcher so that the purpose to which the classification is to be put can be accounted for (Harris, Sleight, and Webber, 2005).

5 Development of Analysis Units (Cases)

The modelling approach outlined above may have relevance for many geodemographic analyses. However, attempting a geodemographic classification of a

small and unevenly distributed minority group raises a second and more specific challenge: the development of an appropriate geographic base. Output Areas (OAs) are the basic building blocks for census output. OAs were specifically devised by ONS to represent homogenous areas as far as the nature of the residential dwellings contained within them is concerned, and have a typical population of about 300 persons. For analysis purposes, small groups of OAs (typically five) have been linked (by ONS) to form lower layer super output areas (LSOAs), and small groups of LSOAs (again typically five) aggregated to form middle layer super output areas (MSOAs), with an average population of 7,800.

Depending on the degree of sophistication being sought, assessments of the total population can be based on any of these levels, in the knowledge that each case will have sufficient population for reliability of characteristics, and cases will be of broadly similar sizes (avoiding any need for weighting of cases). However, simple selection of one geographic level is not appropriate for a classification based on an unevenly distributed minority population, such as Jewish residents of England and Wales (Martin, 1998). Ideally, pre-defined boundaries would be set aside completely, and appropriate case areas identified through examination of micro-level information along the lines described by Spielman and Logan (2013). However, for the current study, confidentiality requirements mean that case areas must be defined from aggregate data which are associated with fixed levels of census geography.

That some individuals identify as Jews on a cultural, ethnic, or secular basis, rather than simply as a matter of religion has been discussed by other researchers (Goldstein, 1992; Graham and Waterman, 2005). The influence of the wording and positioning of the religion question in the England and Wales census on the responses produced, and the extent to which under- or over-reporting might result have also been considered by others (Voas and Bruce, 2004; Graham and Waterman, 2005; Voas, 2007). It must also be acknowledged that responding to the census religion question was voluntary. However, although the 2011 census non-response rate for the question, at 7%, was above, for example, that for ethnic group (3%), address one year ago (5%), or marital status (4%), unlike all other questions, ONS did NOT impute answers to cover non-responses (ONS, 2012). The published outputs for religion thus represent actual responses given by individuals (or those replying on behalf of another household

member). For the purposes of this paper, therefore, and noting the above matters, a Jew is defined as someone who self-identified (or allowed themselves to be identified) as such in the 2011 England and Wales census. The resulting totals from this and the 2001 census are broadly in line with earlier estimates prepared by the Board of Deputies of British Jews using other sources (Schmool and Cohen, 1998).

The average number of self-identifying Jews per MSOA in the 2011 census is 37. Jews are very unevenly distributed across the country. Indeed, 471 MSOAs report zero Jews and, in total, 3759 MSOAs (52% of all MSOAs) report seven or fewer Jewish residents (Source: Census Table KS209EW). It should be noted that, in any event, the record swapping technique which ONS has adopted to prevent identification of individuals (ONS, undated) is likely to mean that information for these MSOAs is not reliable, and a minimum threshold needs to be set for data reliability. Thus, rather than seeking to divide the whole country into appropriate geographic analysis units (as would be the standard approach), large areas of the country which report minimal numbers of Jewish respondents have been omitted for reasons of data reliability.

The term 'accumulation' has been selected as defining geographic areas which delineate places where Jews reside; an alternative term might be 'community', though use of that term could imply some qualitative or social input to the process. Accumulations of Jews to be included in the analysis were selected as follows. As almost 90% of Jews live in MSOAs which are home to at least 18 Jews, that figure was used as an initial threshold. This was modified downwards for urban areas and upwards for rural areas so as to also make some allowance for areal density (as well as density within the wider population) in identifying accumulations. All MSOAs exceeding the threshold were located, and where such MSOAs were adjacent to each other a continuous accumulation was formed. Cluster analysis uses variables which are frequently defined as ratios – for example, the proportion of the population aged under 16, or the proportion of households with two or more cars available. Thus, a minimum accumulation size was set to ensure stability of such measures. This process identified 29 accumulations, each with at least 200 Jewish residents, and which include 237,000 Jews (90% of the England and Wales total).

Table 1 provides a basic summary of the features of the accumulations[1]. The accumulations in Northern England, the Midlands, the South West and Wales are free-standing, whereas in the South East many of the accumulations are almost contiguous with each other and with the large London Area accumulation which includes the majority of Jews in England and Wales.

Considerable information would be lost if all analysis was carried out at the accumulation level (particularly in London). Therefore, data within the accumulations have been examined to identify analysable individual MSOAs and groups of MSOAs. In general, any MSOA accommodating about 300 or more Jews has been regarded as of sufficient size to represent an analysis unit on its own; small MSOAs have been aggregated to produce groups of generally 300 to 700 Jewish residents, in spatially contiguous MSOAs. Furthermore, the 18 most populous MSOAs were replaced by their 92 constituent LSOAs to reduce the range of analysis group population sizes.

The end result is that the original 29 accumulations with 200 or more Jewish residents have been disaggregated, using a hybrid system cutting across the geographic levels, into 407 analysis groups (median size 512 Jewish residents) as follows:

- 14 multi-MSOA whole accumulations
- 172 multi-MSOA parts of accumulations
- 129 single MSOAs (each part of a larger accumulation)
- 92 single LSOAs (each part of the London or Greater Manchester accumulation).

Although the analysis group system described here relates specifically to Jewish residents of England and Wales, the approach could be applied to other ethnic or religion-based groups or, indeed, to many other sub-populations.

6 Identification of Analysis Group Characteristics (Variables)

The final element required to carry out a geodemographic classification of a minority group, such as Anglo-Jewry, is to determine the demographic and socio-economic characteristics of that sub-population, on which the assessment will be based. The 2011 England and Wales census recorded the circumstances of individuals and households on 27 March 2011. Around 50 different characteristics of Jewish respondents in the fields of gender, fertility, migration, age structure, birth country and

[1] Note that the location of the larger accumulations can be found on Figure 1.

ethnicity, household composition, education and employment, and social and well-being measures were developed from data extracted from 2011 census output tables published by ONS. Following others, such as Vickers et al (2003, 2005), the intention was to produce a dataset including variables across the spectrum of demographic, social/living arrangement, education, employment, and housing fields, and thus ensure that a broadly-based classification would be produced. Such are the number of cross-tabulations by religion produced by ONS that this can readily be achieved; data paucity is not an issue here.

In standard census outputs, students are recorded at their term-time address. Students who are living away from their pre-student residence may have only a transient association with their term-time locality. Insofar as understanding the characteristics of the Jewish population of a locality is concerned, particularly if the assessment is intended to shed some light on the future outlook for that population, there is an argument for trying to identify characteristics which reflect the 'host' population, and limit any 'distortion' which the inclusion of students in the derivation of the variables might introduce. A number of the characteristics identified sought to exclude students (from both numerator and denominator).

The initial extraction of characteristics included a number which were simply alternative ways of measuring a single parameter such as fertility, or average age. A first sift thus reduced the number of variables down to 25, and the ranges of values for these characteristics are shown in Table 2[2]. Further preparation of the data, to ensure that: assumptions of normal distribution of variables were not compromised; each variable carried equal weight in the assessment; and to avoid excessive multi-colinearity whilst still ensuring a comprehensive and balanced range of variables; led to the selection of the final 17 variables, as noted in the final column of Table 2 (see Everitt et

[2] The majority of characteristics need no further definition. The fertility indictor is a child:woman ratio based on the number of persons aged 0-9 in the census, and females aged 25-44 – an age range intended to cover the majority of mothers of the 0-9 year olds, whilst avoiding any artificial reduction in the ratio in areas with high numbers of students (aged largely under 25). This fertility indicator can be thought of as a proxy for Total Fertility Rate (TFR). The migration indicator has the same format as the fertility indicator, but compares the number of 25 to 34 year olds (post-student young adults) with the number of females in the previous generation (55 to 64 year olds); only females are counted for the older age band to avoid issues of mortality which might have a measurable impact on males in that age range. Low values of the indicator imply that young adults have moved away from the area; high values that there is in-migration of young adults to the area.

al, 2011; Openshaw and Wymer, 1995; the approach adopted by Vickers et al, 2005; and the advice of Voas and Williamson, 2001).

7 Implementing the Classification process

With the clustering technique in place, geographic cases determined, and population variables identified, the classification process was implemented (using IBM-SPSS software) in accordance with the five step methodology previously described. As required for the correct implementation of Ward's method, the 'distance' between cases and cluster centres was defined as the squared Euclidian distance between the cases, as measured (in this case) in 17 dimension/variable space. For each case, the squared Euclidian distance to its nearest neighbour was determined; the case was considered to be an outlier if this distance was more than 1.5 times the inter-quartile range of such distances above the upper quartile value.

Step 1 identified 18 such outlier cases which were temporarily excluded. Table 3 shows the allocation of the remaining 389 cases to eight to four cluster solutions using Ward's method (Step 2). Table 4 summarises the situation as regards final numbers of cases in each cluster for each potential solution (following the *k*-means clustering and re-introducing of outlier cases – Steps 3 and 4); it also indicates the number of cases which were re-allocated from the cluster in which they had been located in Table 3. Because of the re-allocation of cases (and some slight variation in the allocation of outliers to clusters), the strict hierarchical association between the different solutions in Table 3 is not fully maintained in Table 4 – so the braces in the latter table only provide an indication of the main source of the cluster. The *k*-means algorithm tends to 'shed' cases from combined clusters, and, overall, one in seven to one in four cases has been re-allocated through the *k*-means process.

The novel aspects of the clustering methodology are thus the use of Step 1 and Step 4 to avoid outlier cases distorting the classification, and the application of the *k*-means technique in Step 3 using objectively-determined initial cluster centres rather than potentially local minimum generating random or semi-random 'seed' values.

Having produced five possible classifications, ranging from 4 to 8 classes, the next challenge is to select the 'best' one. There is no standard agreed method for this; indeed Everitt et al (2011) having discussed the issue at some length, conclude by quoting from Baxter (1994) that 'informal and subjective criteria, based on subject

expertise, are likely to remain the most common approach.' The overall process leads to a geodemographic consideration of the characteristics of the population – so it is essential that a spatial element to the determination of the number of classes should be incorporated and, using esri-ArcGIS software, map plots of the various solutions were prepared.

Thus, whilst extensive consideration was given to the quantitative techniques derived from earlier work on classifying census data (Vickers et al, 2003; 2005), the primary input to the determination of the appropriate number of classes to include in the analysis group assessment was a visual and quantitative consideration of the spatial distribution of the different clusters produced by the different solutions. The starting point was the 6-class solution (as summarised in Table 5), in part due to the guidance from the quantitative tests.

In determining which solution to select, consideration has been given to the balance of population between the classes, and the 'stability' of the classes. It would seem prudent to avoid selecting a class which was disproportionately large and might be worthy of sub-division, or one which is transient in the process – for example, a class which exists in the 'n' class solution, but is split into two in the 'n+1' class solution and merged with another class in the 'n-1' class solution; this would imply that the class was not particularly distinct from other classes. Table 5 shows the largest class (D/E) includes 24% of the population but it exists in only this solution; it could be considered as not a very robust grouping.

Moving from 6 to 5 classes would merge Classes D/E and F. Such a merger results in one very dominant Class D/E/F accommodating almost 40% of the Jewish population, and reducing the usefulness of the classification process. Moving from 6 to 7 classes would split Class D/E into separate D and E and produce a solution which is stable over a wider range of classes (see Table 6).

The seven class solution is shown in Figure 1[3]; it displays a clear spatial grouping of adjoining areas in the same classes. A change from 7 to 8 classes would result in splitting Class G into two classes. Unlike the move from six groups to seven,

[3] As the Jewish population is highly urban, a cartogram projection has been used for the monochrome display of the classification – the topology of England and Wales has been distorted such that equal areas include the same total population. A cartogram based on Jewish population could have been used, but the distortion becomes too great for meaningful interpretation of the geography.

which ‘exposes’ a geographically distinct subdivision within a class, the move from seven to eight groups produces a much less clear visual narrative. Clearly, as the number of classes increases, there is scope for greater differentiation between groups; ultimately, however, groups with relatively little difference between them become allocated to different classes, and the increase in class number starts to detract from the spatial element of the assessment. Bearing in mind that aim of the process is ‘to get a good classification of the data that is well suited to the users’ needs’ (Harris, Sleight, and Webber, 2005, p182) the seven class solution is preferred.

8 Analysis of the Classification System

The implementation of the methodology described above yields the first comprehensive picture of the socio-demographic geography of Anglo-Jewry; and, to the author’s knowledge, the first ever geodemographic classification in print which encompasses only a single minority population group. In this section, attention is turned to outlining the geodemographic classes into which the Jewish population falls, disaggregating both mainstream and strictly orthodox Jews, and the geography of these classes. The final section of this paper draws out the wider implications of these results, both for the study of the Jewish population in England and Wales, and for the art of geodemographics more generally.

Table 7 sets out the mean values for each of the 17 variables used in the assessment, for each class; highest and lowest values are emboldened and italicised, respectively. Class C is emphasised by its taking up first or last place in all but two of the variables considered; Class A has a first or last ranking for seven variables. The mean values for each variable for all Jewish Residents and All Residents of England and Wales are also included in the table.

The seven classes fall locationally into three distinct categories: two central/inner urban classes (Classes A and B); two very compactly-formed non-central urban classes (Classes C and D), and three suburban/commuter-belt/coastal classes (Classes E, F, and G). Although there is a geographical similarity between the groups in Class C and D, these similarities are peripheral and coincidental to the main common thread which links groups in both of these classes. All groups in Class C are found in just three locations – Stamford Hill (London), Broughton Park (Greater Manchester), and Gateshead (NE England). Those in Class D are all found in or near Golders

Green/South Hendon (London), and in Broughton Park. The over-riding common theme to these areas is that they are the home to Britain's strictly orthodox Jewish communities (Vulkan and Graham, 2008; Graham, 2013). This overall category is more usefully referred to by a non-geographic tag, Orthodox Enclaves. The classes may be described as follows.

Two classes cover the Jewish population living in *inner urban* areas:

Class A - Footloose cosmopolitan professionals. This class has a low proportion of 0 to 15 year olds, and a very high proportion of single person households. The level of cohabitation is very high, and home ownership is low. The class has a particularly low fertility level, and a very high proportion holding a degree, with professional and technical employment levels, and higher and middle management positions also higher than all other classes. The proportion born in the UK is very low, and the class has a strong central London focus (57 contiguous analysis group areas). The only other Class A groups are found in Oxford and Cambridge, whose universities have a strong international pull.

Class B - Blue-collar and student urbanites. This class also has a low proportion of 0-15 year olds and a high proportion of single person households; outside of London there is a strong student focus to the class. The ratio of 30 year olds to 60 year olds is high indicating in-migration of young adults (but producing relatively few children). Self-employment is below average (compared with the Jewish population as a whole). The class also exhibits the highest proportion of lone-parent families, and an above average level of room overcrowding and low levels of home and car ownership. Geographically, the student groups in this class are located in provincial towns and cities with popular universities; all other provincial Class B groups are located adjacent to student groups in the major conurbations. The major concentration of non-student Class B groups is in inner north east London.

Two classes fall within *orthodox enclaves,* and their characteristics are highly influenced by the centrality of strict observance of religious precepts in the lives of their residents:

Class C - Very young deprived traditionalists. Class C has a very high fertility rate and complementary to this feature, over half the Jewish population of Class C is aged below 16, with a very low proportion aged 65 or more. The proportion of adults

who are looking after home or family is extremely high as is the proportion engaged in education employment. This class also exhibits high levels of room overcrowding, very low levels of home and car ownership, and very low levels of (secular) educational qualifications.

Class D - Young fairly comfortable conservatives. This class also has a much higher than replacement fertility rate (but less than half the value of Class C), with a proportion of 0 to 15 year olds noticeably higher than average, and employment in education also well above average. However, in areas such as professional and technical employment, degree level qualifications, room overcrowding, home and two-car ownership, this class achieves closer to average performance.

Three classes located in *suburban, commuter-belt, and coastal* towns, sharing average levels of self-employment, professional and education employment, and level of cohabitation:

Class E - Comfortable educated suburbanites and *Class F - Affluent home-grown commuters.* Both these classes display fertility around replacement levels, and average proportions of 0-15 year olds and of those aged 65 and more. However, Class E varies from Class F in having a noticeably-higher proportion of higher and middle managers, and above average proportion of degree holders, and an average rather than very high proportion of people born in the UK. The number of single person households is slightly higher for Class E than F. Class E appears to be slightly less affluent that Class F – the level of room overcrowding is around the wider average (whereas Class F is very low); home ownership, whilst above average is lower than Class F. Similarly, 2-car availability, whilst above average is noticeably below that for Class F. There is a distinct pattern to these groups' geographic locations. Class E groups are to be found almost entirely in two distinct areas - the southern part of the London Borough of Barnet, and a large area of south west London, Surrey and Berkshire. Class F groups are to be found primarily in Greater Manchester, and in a large area covering much of Hertfordshire, Essex, parts of adjoining counties, and the northern part of the London Borough of Barnet.

Class G - Comfortable home-grown elders has an average age which is higher than the other classes, a very low proportion of 0-15 year olds, a very high proportion of those aged over 65, a slightly below average proportion of people employed in

professional and technical occupations, and a high proportion born in the UK. The proportion of single person households is high, of whom the proportion aged over 65 is also high, reflecting the age profile of the class. Fertility levels for the class are well below replacement. The class has an average level of room shortage and car ownership, and a slightly above average level of home ownership. Class G groups are found in major parts of most larger provincial accumulations, coastal/resort towns, and the NW and NE fringes of Greater London.

Further insight into the nature and future prospects for areas which fall into the various classes can be gleaned through an examination of population pyramids produced by summing the age by gender census data for the groups in each class (as shown in Figure 2). The pyramids for Class A and Class B share some similarities. They both exhibit a population bulge; Class A drawing in young professionals (age 25-40) with Class B marked by a large student influx. Both groups have similar short bands for the 0 to 14 age groups – emphasising the low fertility rate for these classes. If it were not for in-migration (from elsewhere in Britain, or from overseas), both these classes would be shrinking rapidly, so the future prospects for areas in both classes will be influenced by their continuing attractiveness to specific age groups.

The population within Class C with its strong concave triangular shape can be expected to increase very rapidly with time. Class D exhibits a 'watered down' version of the Class C pyramid, with some student loss and young adult bulge, and a much larger older person presence; this class will also be expanding.

Class E and F pyramids indicate some stability, with the numbers in the 0-14 age bands being broadly similar to those in their thirties to fifties. Both classes do show a defined loss of those of student age. The inverted triangle nature of the Class G pyramid implies a declining population size. Although mortality prevents the triangular form widening further into the post 70 age groups, those age groups nevertheless have a larger representation than any of the under 50 year old bands.

An indication of the scale to which the various accumulations of 200 or more Jewish residents are likely to be expanding or contracting can be deduced by considering the balance of different classes present in the analysis groups which form each accumulation. This information is summarised in Table 8 which lists the accumulations (with the large London and Greater Manchester areas subdivided into

smaller areas) starting with those expanding fastest and finishing with those shrinking most rapidly.

9 Discussion and Conclusions

The inclusion of a question on religion in the England and Wales census, and the cross-tabulation of religion with a large number of socio-economic, demographic and household structure variables in the census outputs have permitted a detailed examination of the characteristics of Anglo-Jewry in 2011 to be carried out. For the most part, the averages for Jewish residents are not materially different than for all residents of England and Wales. Notable exceptions to this are: the level of self-employment (16% of employed persons for all residents, but 30% for Jewish residents); degree qualified (27% and 42% of over 16s); and professional and technical employment (7% and 16%, respectively). It is, therefore, briefly worth considering whether the classification produced merely reflects the characteristics of the wider population in the relevant areas, or whether there is a distinctiveness to the Jewish classification; do the 'tags' used to refer to each class also apply to the residents of the areas more generally?

Table 9 lists those characteristics where the values for Jewish and other residents differ noticeably. The table shows that the greatest confluence between characteristics occurs in Class B and Class E areas, with the widest divergence in Class C and D areas. In these latter areas the very high fertility levels (and consequent proportion of persons aged 15 or under) displayed by the Jewish residents are not repeated in the wider community, though these are not the only differences. Perhaps more unexpected is that Jewish residents of both Class D and G areas are more likely to be UK born than their neighbours. Overall, whilst inevitably all residents of areas share a number of characteristics (as the nature of area infrastructure, such as housing types and tenure availability have an influence on all residents), the conclusion is that there is a distinctiveness to the classification produced through analysing a small sub-population.

In developing this classification, the largest challenge – that of developing a suitable geographic base for the small size and very uneven distribution of the Jewish population of England and Wales in 2011 – has been successfully overcome, and could be applied to other minority groups in the UK or elsewhere.

It has long been recognised that strictly orthodox Jews form a visually and locationally distinct element within the wider Jewish population of England and Wales (Vulkan and Graham, 2008; Graham, 2013), and that there is a degree of socio-economic deprivation and attitudinal differences between that grouping and 'mainstream' Jews (Holman and Holman, 2002; Valins, 2003).

The geodemographic assessment presented in this paper is the first to examine the Jewish population of England and Wales in its totality. The classification results are easily distinguishable both geographically and in terms of socio-economic and other characteristics. Indeed, the analysis has demonstrated that the strictly orthodox community can itself be considered as two classes. More importantly, the assessment has shown that there is considerable heterogeneity amongst 'mainstream' Jews. Geographically, there is a clear division between inner urban Jews and suburban/commuter-belt/coastal Jews, with distinct classes within each of these two wider categories. In terms of major demographic characteristics, there is a wide-ranging diversity in fertility levels between the various classes identified – from very high levels leading to a rapid expansion of the class, to levels which are around 50% of replacement levels. The latter class (Class A - Footloose cosmopolitan professionals) appears to be sustained by extensive in-migration of young adults. Conversely, the below-replacement fertility of Class G - Comfortable home-grown elders is compounded by out-migration of young adults. The population pyramid for Anglo-Jewry as a whole (see Figure 2) indicates a high level of stability; however the underlying analysis indicates that this is merely co-incidental, and masks patterns of significant expansion and contraction in different geodemographic classes which, by chance and at the present time, happen to cancel each other out overall.

This paper has demonstrated that a geodemographic assessment of a sub-population is possible, even for a grouping which makes up only 0.5% of the national population and is geographically very unevenly distributed. In technical terms the paper has addressed the challenges of outliers and local minima through the development of a methodology which carefully combines both hierarchical and optimising clustering techniques. Substantively, the paper has shown that there are wide socio-economic differences within Anglo-Jewry, but that there is a strong degree of spatial clustering too. The analysis presented here both confirms and contradicts Tobler's *First Law of*

Geography, which states that 'everything is related to everything else, but near things are more related than those far apart' (Tobler, 1970, p236). Certainly, the assessment shows that there is a high level of homogeneity at a local level – many adjoining analysis areas fall into the same class even though the Jewish population of the analysis units is, on average, fewer than 600. It is also true that some localities at a distance from each other present quite different socio-economic and other characteristics. However (contrary to the 'law'), it is possible to find localities/populations in widely separated parts of the country which share characteristics and class allocation.

Spielman and Thill (2008) reached an almost identical conclusion as regards Tobler's First Law and the spatial distribution of population characteristics in their study of New York. Their technique did not use geodemographic assessment in a traditional form; instead they combined a topographic representation of the distribution of cases with their locational positioning in a Kohonen Self-Organising Map algorithm (SOM) (Kohonen, 2001; Yan and Thill, 2009; Openshaw & Openshaw, 1997)[4]. Nevertheless, the type of clustering patterns found in the current study's UK sub-population are also found in studies of the whole population of areas.

Carrying out a geodemographic analysis should not be seen as an end in itself. However, 'identifying geographical patterns or trends within societies is an important step towards understanding the processes and phenomena that give rise to those patterns in the first place' (Harris, Sleight, and Webber, 2005, p14). The analysis described in this paper could thus form an essential foundation to a more extensive geo-social or demographic assessment/projection of Anglo-Jewry, and it could be applied to other minority groups and in other localities.

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[4] Whilst Spielman and Thill's (2008) approach could have been used to form, for example, a 7-class classification of the New York area instead, they allocated the 2217 census tracts to 1350 'buckets' (p114). On the SOM, similar buckets are located in close proximity, allowing the user to group (classify) census tracts through arbitrary or regular sub-division of the SOM, which is linked to a topographic representation of the tract locations.

under the Open Government Licence v.2.0, and all census tables referred to can be accessed via http://www.nomisweb.co.uk/census/2011/data_finder.

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Table 1 Basic Characteristics of Jewish Accumulations in England and Wales, 2011

Accumulation	No of MSOAs	**Jewish Residents**	Jewish Residents per 100 Ha	Jews per 100 Usual Residents	Proportion of E&W Jews	Proportion students (if >15%)
Newcastle	23	**660**	3	0.28	0.3%	
Gateshead	14	**2,939**	68	2.82	1.1%	34%
Leeds	73	**6,850**	14	1.29	2.6%	
Hull	17	**244**	3	0.18	0.1%	
Sheffield	22	**544**	6	0.29	0.2%	26%
Gtr Manchester Area	164	**24,630**	27	1.87	9.4%	
Liverpool	30	**2,023**	35	0.86	0.8%	
Southport	12	**349**	6	0.38	0.1%	
Blackpool & St Annes	27	**567**	8	0.27	0.2%	
Birmingham & Solihull	54	**1,871**	14	0.43	0.7%	38%
Warwick	8	**208**	3	0.25	0.1%	31%
Nottingham	39	**1,366**	7	0.44	0.5%	54%
Leicester	11	**299**	13	0.27	0.1%	17%
Southend	42	**2,665**	10	0.72	1.0%	
Norwich	16	**263**	5	0.17	0.1%	21%
Cambridge	25	**1,105**	3	0.52	0.4%	31%
Luton	21	**326**	8	0.16	0.1%	
Milton Keynes	26	**421**	2	0.20	0.2%	
Oxford	25	**1,194**	8	0.56	0.5%	35%
Worthing	19	**343**	6	0.22	0.1%	
Brighton	64	**3,380**	5	0.65	1.3%	
Eastbourne	19	**330**	1	0.22	0.1%	
Sevenoaks & Borough Gn	10	**210**	1	0.23	0.1%	
Canterbury & Whitstable	12	**200**	2	0.20	0.1%	27%
Thanet	12	**220**	7	0.23	0.1%	
London Area	1368	**180,410**	26	1.63	68.5%	
Bournemouth	52	**2,007**	5	0.48	0.8%	
Bristol	23	**605**	18	0.32	0.2%	34%
Cardiff	28	**714**	8	0.34	0.3%	
All accumulations	2256	**236,943**	19	1.29	90.0%	
All other areas	4945	**26,403**	0.2	0.07	10.0%	
England and Wales TOTAL	7201	**263,346**	1.7	0.47	100.0%	

Source: Derived from Census Tables KS209EW, DC1202EW, DC6205EW, and KS101EW

Table 2 2011 Values of Characteristics for Analysis Groups

Characteristic	10th %ile	lower quartile	Median	upper quartile	90th %ile	Mean	Transformed/ Used in Assessment
Total Fertility Indicator (all 0-9 / females 25-44)	0.82	1.18	1.66	2.33	4.44	2.18	Cube Root
Migration Indicator (25-34/females 55-64)	0.57	0.97	1.73	3.66	5.74	2.71	Cube Root
Average Age (exc students)	32.3	39.1	44.4	50.7	55.8	44.1	NOT used
Proportion age 0-15 (exc students)	0.09	0.13	0.17	0.25	0.38	0.21	Logarithm
Proportion age 65 and over (exc students)	0.09	0.15	0.22	0.31	0.41	0.24	Square Root
Proportion economically 'inactive'	0.22	0.27	0.34	0.41	0.49	0.34	NOT used
Proportion self-employed (of employed)	0.20	0.25	0.30	0.35	0.39	0.30	Not transformed
Proportion looking after home or family (of inactive)	0.04	0.07	0.12	0.20	0.31	0.15	Square Root
Proportion in higher/middle managerial roles (of all employed)	0.40	0.47	0.55	0.63	0.71	0.55	NOT used
Proportion with no qualifications (of 16+)	0.06	0.10	0.15	0.24	0.34	0.18	Square Root
Proportion with degree qualifications and above (of 16+)	0.19	0.31	0.42	0.54	0.64	0.43	Not transformed
Proportion of employed in wholesale and retail trade	0.08	0.11	0.14	0.17	0.20	0.14	Not transformed
Proportion of employed in professional, scientific and technical areas	0.08	0.12	0.16	0.19	0.23	0.16	Not transformed
Proportion of employed in education	0.07	0.09	0.12	0.16	0.26	0.14	Logartithm
Proportion of employed in health and social work	0.07	0.09	0.11	0.13	0.15	0.11	NOT used
Proportion UK born	0.67	0.74	0.82	0.90	0.94	0.81	Square
Proportion white-British ethnic group	0.56	0.68	0.78	0.88	0.92	0.76	NOT used
Proportion non-white ethnic group	0.02	0.04	0.06	0.10	0.15	0.08	NOT used
Proportion single person	0.17	0.24	0.33	0.40	0.48	0.32	Not transformed
Proportion married or civil partnership (of families)	0.47	0.54	0.63	0.70	0.79	0.62	Not transformed
Married as proportion of married + cohabiting	0.74	0.82	0.90	0.95	0.98	0.87	Cube
Proportion of households short of room or bedroom	0.02	0.04	0.06	0.13	0.20	0.09	NOT used
Proportion of households in owned or shared ownership tenure	0.44	0.63	0.77	0.86	0.91	0.72	Square
Proportion of households with zero cars	0.05	0.09	0.16	0.29	0.43	0.20	NOT used
Proportion of households with 2 or more cars	0.09	0.19	0.33	0.47	0.57	0.34	Not transformed

Source: Calculated from 2011 Census Tables: DC/LC1202EW, DC/LC2107EW, DC/LC2201EW, DC/LC2207EW, DC/LC4202EW, DC/LC4207EW; DC/LC4208EW, DC/LC5204EW, DC/LC6205EW, DC/LC6207EW, and DC6212EW

Table 3 Allocation of Cases to Clusters: Ward's method, Groups excluding outliers

	Number of Cases allocated to each cluster								Number of Clusters formed
Cycle / Cluster	***i***	***ii***	***iii***	***iv***	***v***	***vi***	***vii***	***viii***	
381	27	16	80	59	63	36	65	43	8
382	27	16	80	59	63	36	108		7
383	27	96		59	63	36	108		6
384	27	155			63	36	108		5
385	27	155			99		108		4

Table 4 Allocation of Cases to Clusters: k-means method including all cases

	Number of Cases allocated to each cluster								Number of Cases Re-allocated	Number of Clusters formed
Cluster	***i***	***ii***	***iii***	***iv***	***v***	***vi***	***vii***	***viii***		
	30	23	58	56	59	52	81	48	92 (24%)	8
	30	23	70	76	62	48	98		68 (17%)	7
	32	83		79	64	48	101		68 (17%)	6
	33	133			71	58	112		55 (14%)	5
	33	143			104		127		60 (15%)	4

Table 5 Allocation of groups and population to classes – 6 class solution

Class	No of Groups	Jewish population	Proportion of population	Exists in solutions with
A	64	32445	14%	5 to 9 classes
B	48	21459	9%	5 to 13 classes
C	32	25445	11%	2 to 21 classes
D/E	83	56293	24%	6 classes only
F	79	49853	21%	6 to 12 classes
G	101	51448	22%	4 to 7 classes

Table 6 Allocation of groups and population to classes – 7 class solution

Class	No of Groups	Jewish population	Proportion of population	Exists in solutions with
A	62	31317	13%	5 to 9 classes
B	48	21459	9%	5 to 13 classes
C	30	23610	10%	2 to 21 classes
D	23	21256	9%	7 to 31 classes
E	70	39740	17%	7 and 8 classes
F	76	49495	21%	6 to 12 classes
G	98	50066	21%	4 to 7 classes

r Variables used in the Classification Process

iables		Socio-Economic Variables									Household structure Variables		
65+ yrs	British born	no qualifi-cations	degree qualifi-cations	self-employed	looking after home	retail employ-ment	technical employ-ment	education employ-ment	owned house-hold	2 car house-hold	1 person house-holds	married house-holds	married proportion (of married + cohabiting)
0.20	*0.64*	*0.09*	**0.62**	0.32	0.14	*0.09*	**0.21**	*0.09*	0.60	0.17	0.42	0.58	*0.76*
0.23	0.80	0.19	0.39	0.24	0.08	0.14	0.12	0.15	0.56	0.21	**0.43**	*0.51*	*0.76*
0.06	0.76	**0.39**	*0.14*	*0.17*	**0.46**	0.16	*0.06*	**0.37**	*0.39*	*0.07*	*0.15*	**0.88**	**0.98**
0.17	0.76	0.17	0.38	0.29	0.26	0.14	0.15	0.21	0.70	0.33	0.24	0.75	0.97
0.19	0.78	*0.09*	0.58	0.33	0.18	0.11	0.19	0.13	0.80	0.40	0.29	0.67	0.90
0.22	**0.90**	0.14	0.42	**0.34**	0.16	**0.17**	0.18	0.11	**0.89**	**0.59**	0.23	0.68	0.93
0.38	**0.90**	0.27	0.31	0.30	*0.06*	**0.17**	0.14	0.12	0.81	0.34	0.38	0.53	0.88
0.23	0.81	0.18	0.42	0.30	0.13	0.14	0.16	0.13	0.73	0.36	0.33	0.64	0.88
0.18	0.87	0.23	0.27	0.16	0.13	0.16	0.07	0.10	0.64	0.32	0.30	0.65	0.77

Table 8 Main classes present in each Accumulation

Main classes of groups	Accumulation (or subdivision of London and Gtr Manchester areas)
	Likely to be expanding at fastest rate
C	Stamford Hill; Gateshead.
Balance of C & D	Broughton Park.
D	Golders Green and Hendon South.
F with some D	Edgware, Mill Hill, & Totteridge.
F	Epping Forest, W Essex & E Herts; West Herts & East Bucks; Trafford South, Stockport & E Cheshire.
F with some E	Hertsmere, Hatfield, & London Colney.
F with some E & G	East & High Barnet, & Cockfosters
E	Hampstead, East Finchley and Muswell Hill; South West London; Central and West Surrey; Sevenoaks & Borough Green.
E with some B	St Albans and North Herts.
E with some G	Finchley & North Hendon; Reading & Maidenhead; Bromley.
Balance of A & E	Oxford; Cambridge.
A	Central and Inner North West and South London.
B	Inner East and North-East London; Manchester and Salford Central; Croydon and Streatham; Bristol, Sheffield, Milton Keynes, Norwich, Warwick, Canterbury.
B with some G	Nottingham; Cardiff.
Balance of G & B	Birmingham & Solihull; Brighton; Newcastle.
G with some B & F	Leeds; Liverpool.
G with some F	Harrow, Hillingdon & Wembley; Prestwich, Whitefield, & Bury; Enfield Town & Broxbourne; Sutton & Epsom.
G	Redbridge, Havering, & Chingford; Southend on Sea; Bournemouth; Blackpool & St Annes, Southport, Worthing, Eastbourne, Luton, Leicester, Hull, Thanet.
	Likely to be shrinking at fastest rate

Table 9 Comparison of Characteristics of Jewish and other residents

Class	Tag	Characteristic	Jewish Residents	All other residents
A	*Footloose cosmopolitan professionals*	Age 65 and over	20%	10%
		Self-employed	32%	18%
		Degree qualified	62%	46%
B	*Blue-collar and student urbanites*	Age 65 and over	23%	13%
		Single-person households	43%	33%
C	*Very young deprived traditionalists*	Fertility indicator	7.4	1.6
		Age 15 and under	56%	20%
		Looking after home	46%	14%
		Employed in education	37%	10%
		Married proportion of partnerships	98%	69%
D	*Young fairly comfortable conservatives*	Fertility indicator	4.1	1.5
		Age 15 and under	36%	21%
		UK born	76%	54%
		Home owner	70%	48%
E	*Comfortable educated suburbanites*	Self-employed	33%	18%
		Degree qualified	58%	40%
F	*Affluent home-grown commuters*	Self-employed	34%	19%
		Professional/technical employment	18%	9%
		Two car availability	59%	43%
G	*Comfortable home-grown elders*	Migration indicator	1.0	2.3
		Age 65 and over	38%	18%
		Self-employment	30%	17%
		UK born	90%	83%

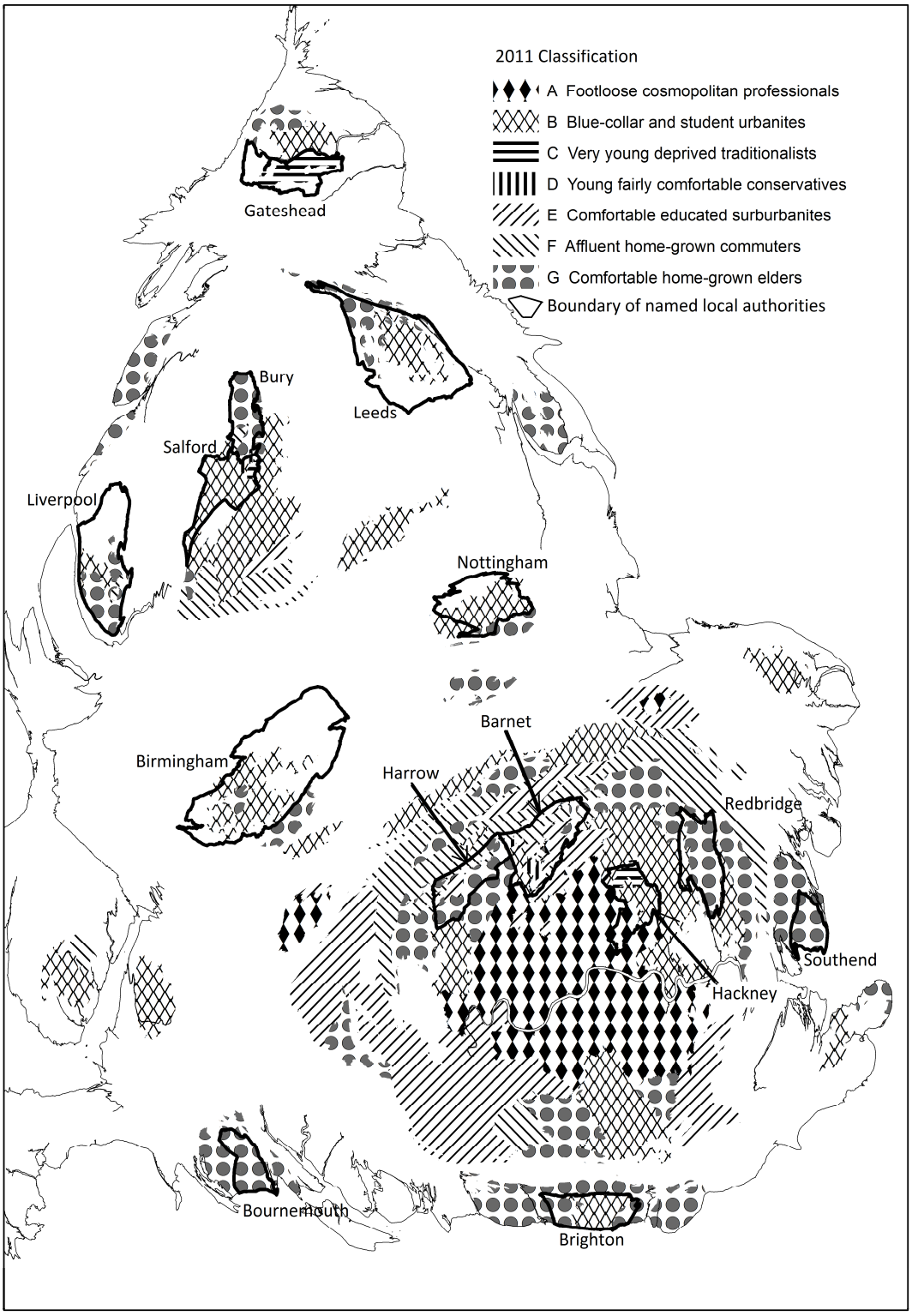

Figure 1 Group Classification based on 7 classes (monochrome version)

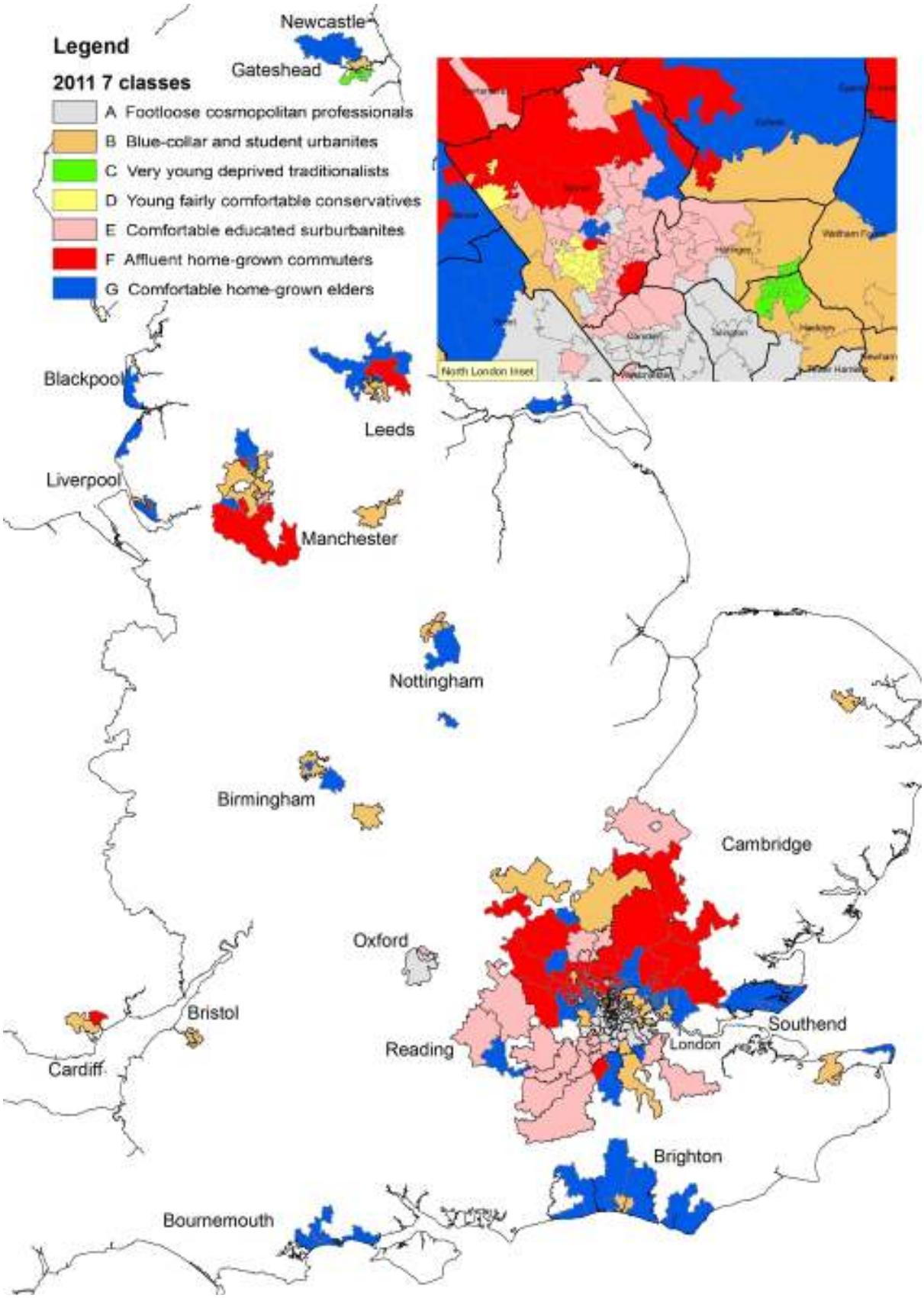

Figure 1 Group Classification based on 7 classes (colour version)

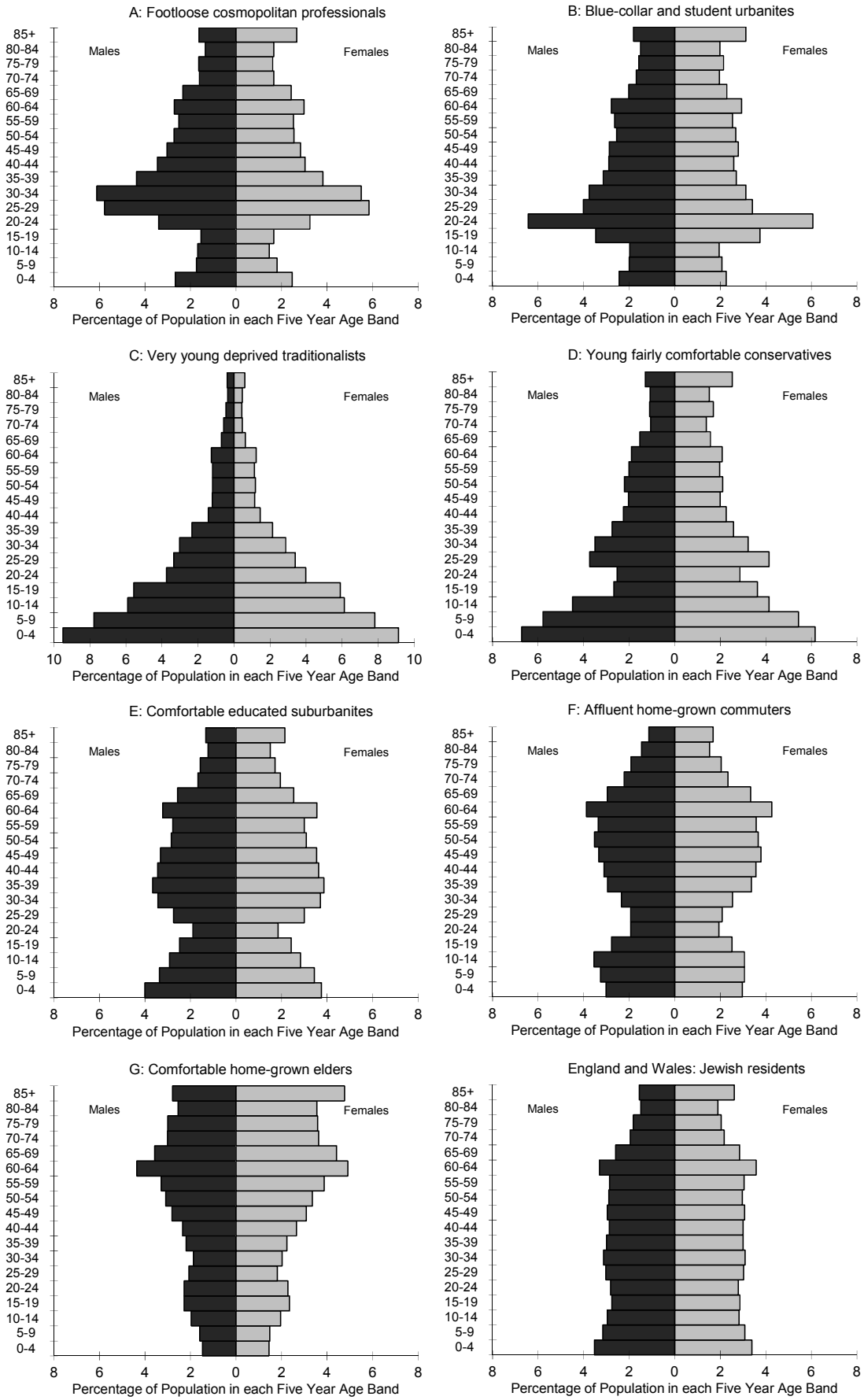

Figure 2 Jewish Population Pyramids