Commentary

Socioeconomic segregation in UK (secondary) schools: are index measures still useful?

Introduction

Socioeconomic segregation within UK schools remains an important research topic given that schools with an overconcentration of pupils from disadvantaged families tend to have lower educational attainment which has a detrimental effect on pupils' life chances (Coldron et al, 2010; Croxford and Paterson, 2006; Gorard, 2009). Debate continues about the measurement of segregation, with recent contributions from Allen and Vignoles (2007); Cheng and Gorard (2010), Gorard (2007; 2009; 2011), and Johnston and Jones (2010; 2011) about the choice of an aspatial index and Harris and Johnston (2008), Harris (2011; 2012), and earlier work by Gibson and Asthana (2000) who assess spatial measures.

Most UK studies use the take-up of and, since 1993, eligibility for free school meals (FSM), to differentiate pupils by socioeconomic status, whereas Harris and Johnston (2008) examine school segregation by ethnic group [see also US studies by Reardon et al (2000) and Frankel and Volij (2011)].

In this comment I argue that (i) some recent claims about the properties of aspatial indexes are incorrect; and (ii) notwithstanding advances in the conceptualisation of spatial segregation, the structural features of UK school segregation are such that a meaningful interpretation of changes (differences) in index magnitudes over time (across space) is highly problematic, so that locally focused case studies represent a superior approach.

Measuring school segregation

The distribution of FSM pupils and those who are ineligible (NFSM) across n schools can be represented as an $n \times 2$ segregation matrix with its ith row representing the number of FSM and NFSM pupils in school i.

Allen and Vignoles (2007) argue that the index of dissimilarity (ID) exhibits the desirable properties of scale interpretability, size invariance, symmetry across groups and schools, school equivalence (SE), and the principle of transfers. Except for scale interpretability (see below), these properties are appropriate, but insufficient to underpin an index designed to track changes in school segregation through time, due to the impact of changing overall shares of (N)FSM pupils and changing total enrolments across schools. Thus, an index of school segregation should ideally be characterised by both composition invariance (CI) and schools invariance (SI). CI refers to the index being invariant to an equiproportionate change in the elements of a column of the segregation matrix, say FSM pupils, with the other column remaining constant. SI refers to invariance following a change in total enrolments at school i, but with its socioeconomic composition of pupils (ie, FSM share) remaining unchanged.[1]

An index satisfying CI and SI is margin free (MF) because its magnitude is independent of equiproportionate changes in the elements of a column or a row of the segregation matrix. If the chosen index does not satisfy these two criteria, margin dependence will always condition changes in its magnitude.

No segregation index satisfies the four properties, and also SI and CI, however, because SE and SI are inconsistent. SI and symmetry by organisation imply a constant, uniform

[1] Watts (1998) and Mora and Ruiz Castillo (2011) support margin-free measurement of occupational gender segregation, but Jerby et al (2006) view the overall female employment share as integral to the segregation process which reflects the family division of labour, and hence government policy, as well as firms' recruitment behaviour. An analogous argument is not applicable to school segregation.

set of school weights ($1/n$) in the index calculation. This is unsatisfactory because schools differ in size which should be reflected in their weights and is required by SE [see Watts (2003) in reference to occupational segregation]. A solution is to find an index satisfying Allen and Vignoles's criteria, excluding scale interpretability, from which an MF change in segregation over time can be derived.

The Deming and Stephan (1940) (DS) data transformation enables the absence of CI and SI to be finessed. Consider segregation matrices for years 1 and 2 based on a consistent set of schools. A new socioeconomic distribution of pupils in each school can be generated by successive transformations of rows and columns of the year-1 segregation matrix until their respective sums are aligned with those in year 2, subject to an error of say 0.1%.[2]

The transformed pattern of year-1 enrolments reflects the year-1 composition of pupils across schools. Segregation matrices for all years can be transformed, so that their row and column sums correspond to those in the base year (year 2). The index values based on this consistent time-series dataset are MF and directly comparable.

SE is not sacrificed, because SI and CI criteria are finessed. Scale interpretability is irrelevant, because year-to-year comparisons of MF index magnitudes are based on a constant upper bound, whereas comparisons of margin-dependent measures, even with scale interpretability, so that the index lies between 0 and 1, are largely meaningless.

Competing indexes

Gorard and Taylor (2002) argue that school segregation should be measured by GS, namely:

$$\text{GS} = 0.5\sum_i \left| \frac{F_i}{F} - \frac{T_i}{T} \right| = \left[\left(\frac{1}{2T}\right)\sum_i | F_i - \alpha T_i | \right] \Big/ \left(\frac{F}{T}\right) = \left(\frac{N}{T}\right)\text{ID} , \qquad (1)$$

where F_i, N_i, T_i are the number of FSM and NFSM pupils and total enrolments, in school i ($i = 1, 2, ..., n$). N, and T represent the corresponding aggregates and α is F/T. The term in square brackets is the KM index (Karmel and Maclachlan, 1988) and ID is the index of dissimilarity.

GS satisfies three of the five properties outlined by Allen and Vignoles. Its upper bound is N/T, so scale interpretability is not satisfied. The absence of group symmetry means that GS*, can be defined with F_i and F being replaced by N_i and N, respectively, and vice versa. These indexes could move in opposite directions.

Gorard and Taylor (2002, pages 881, 885) appear to accept the criteria of CI and SI, because they quote standard definitions in Watts (1998), but their definition of strong CI (SCI) is based on a uniform increase of FSM pupils in each school with total enrolments usually remaining unchanged: that is, both F_i/F and T_i/T ($i = 1, ..., n$) stay constant. Later Gorard (2011, page 5) incorrectly reasserts that the GS index is CI, as defined by Reardon and Firebaugh (2002, page 38). A rise in the FSM share, with F_i/F and N_i/N ($i = 1, ..., n$) remaining constant, leads to a fall in GS [see equation (1)], since ID is CI, as usually defined, (see Gibson and Asthana, 2000, page 134; see also Allen and Vignoles, 2007). In response to Gorard (2007, page 672), who claims that "Almost any index will do", Johnston and Jones (2010, page 1264) emphasise the methodological point that the chosen index "has wider value for the study of segregation".

The asymmetric form of invariance associated with GS is considered to be the best way to address the redefinition of low-income pupils from FSM take-up to eligibility (Cheng and Gorard, 2010, page 415; Gorard, 2009; 2011). Periodic data redefinition is the bane of rigorous time-series research. The availability of the better FSM measure based on eligibility would

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[2] The iterative process is analogous to the solution procedure for a doubly constrained entropy model in which matrix elements are estimated subject to row and column constraints (see O'Kelly et al, 2012).

usually be addressed by splicing index magnitudes in 1993 based on the two definitions, so the primary justification for GS cannot be sustained. Also, UK school segregation studies are increasingly based on ethnicity (eg, DfES, 2006; Hamnett, 2012; Harris and Johnston, 2008; Johnston et al, 2008), rather than FSM eligibility, and there is no multigroup analogue of GS.

Johnston and Jones (2010, page 1267) consider the IS index, which simplifies to ID in the two-group case,[3] but advocate the use of the nonlinear isolation index:

$$\text{II}_F = \sum_i \left(\frac{F_i}{F}\right)\left(\frac{F_i}{T_i}\right). \tag{2}$$

The index measures the probability that, if an FSM pupil is selected at random, then another individual selected at random from the same school is also an FSM pupil. A normalised index is advocated, because its minimum value is F/T:

$$\text{MII}_F = \left(\text{II}_F - \frac{F}{T}\right)\Big/\left(1 - \frac{F}{T}\right), \tag{3}$$

which exhibits scale interpretability, so it lies between 0 and 1. MII_F is alleged to exhibit CI (page 1268) but it fails to conform to either CI or SCI (cf Johnston and Jones, 2010, tables 1, 2, page 1266), although it should be noted that CI is not a useful property for a gross index. Finally, the NFSM-based definition of isolation could be considered equally suited to analysing school segregation (see table 1) and also exposure indexes. Multigroup (ethnic) segregation yields a series of pairwise exposure indexes, in addition to an isolation index for each group, which makes meaningful interpretation difficult.

Structural features of UK school segregation
School closures and new schools
The number and composition of UK schools changed markedly after the first 'city academy' opened in 2002. Academisation accelerated after the Education Act (2010). By November 2012, 2456 had opened out of 4028 schools. Half of maintained secondary schools in England are now academies, of which 536 are sponsored, so the remainder are 'converter' academies. Academies can select up to 10% of pupils by ability (Academies Commission, 2013, page 16).

Segregation trends are designed to capture the impact of legislative change. However, the change in the number (and composition) of schools creates serious problems of interpretation. When a school closes and pupils relocate, the impact on gross segregation is ambiguous, depending on whether FSM (NFSM) pupils relocate to schools where they are overrepresented. If all pupils join the same school, a linear segregation index, such as ID, cannot increase and may fall.[4] A new school may attract a high proportion of say NFSM pupils which may raise segregation.

The changing population of schools creates a major dilemma if MF measurement is required, because the DS transformation requires a constant population of schools, so a school in year 1 can be mapped into the same school in later years. The removal of schools which opened or closed during the sample period creates a bias in the calculations, because, when a school did not exist, some pupils, who earlier or later attended those schools, attended other schools which are included in the calculations. Use of synthetic data for absent schools has minimal influence on the gross index, if it exhibits SE, but could have a major influence when constructing an MF time-series dataset.

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[3] They object to the term F_i (and F) also appearing in the second term of the expression for GS, which signifies double counting.

[4] School closures were associated with falling segregation 1999–2004 (Allen and Vignoles, 2007, page 659; see also Gorard et al, 2002).

Impact of the business cycle

The measure of pupils' socioeconomic status (eligibility for FSM or other income-related measures) is sensitive to the business cycle (Gibson and Asthana, 2000), but the business cycle is outside the influence of national education policy and the selection policies of schools, although schooling choices of some parents may be influenced. Thus, the chosen index should nullify the impact of the business cycle on pupil classification, particularly in the light of the global financial crisis.

A major recession would increase FSM pupils in most schools, with the dominant influence being the number of NFSM pupils whose status would be affected. Thus more affluent schools become relatively more deprived, thereby reducing segregation (Cheng and Gorard, 2010; Harris and Johnston, 2008). Conversely, in an upturn the decline of FSM pupils would be driven by the previous number of FSM pupils in a school. GS would be appropriate to address a uniform decline of FSM pupils, whereas GS* would be more suitable during a recession. Consequently, the use of a single index, such as GS, to purge the artifactual impact of the cycle on the FSM share would constitute a misspecification. Cheng and Gorard (2010) recognise the difficulty of interpreting recent changes in segregation in the presence of a rising overall FSM share.

Eligibility for FSM is also a poor proxy for low income (Hobbs and Vignoles, 2009, page 685). The variability of this metric which is designed to calibrate socioeconomic status suggests that measuring segregation across ethnic cohorts is more appropriate, notwithstanding some ambiguity in defining ethnicity.

Spatial school segregation

National evenness measures of school segregation are based on the overall socioeconomic composition of pupils being the benchmark against which schools' compositions of pupils are measured,[5] which implies the presence of universal segregative and integrative forces, as opposed to local education authority (LEA) or local market influences (Allen and Vignoles, 2007; Gibson and Asthana, 2000; Taylor et al, 2003). Before the UK Education Reform Act (1988), LEAs could perhaps be considered to be the natural spatial units within which segregation could be measured. Pupils were allocated a comprehensive school place based on where they lived in the LEA although most LEAs "are far too large to constitute a single market" (Gibson and Asthana, 2000, page 139; but see Allen and Vignoles, 2007).

Now "parents can express a ranked preference for between three and six (depending on the LEA) schools anywhere in England ... [T]he LEA allocates prospective pupils into available places using pre-specified admissions criteria, with the exception of Academies, foundation and voluntary-aided schools which control their own admissions" (Singleton et al, 2011, page 241). Most LEAs favour prospective pupils living close to oversubscribed schools, but formal appeal procedures do operate (Coldron et al, 2010; Singleton et al, 2011). Thus, since the 1988 reforms, which were designed to make the allocation process more market driven, ostensibly to enhance educational outcomes and reduce polarisation (Gibbons and Asthana, 2000), and also the subsequent process of academisation, LEAs have become even less appropriate as the spatial unit.

Using a sample of 457 nonselective county-maintained and grant-maintained schools, Gibson and Asthana (2000) used pupil postcodes to establish local markets for each school consisting of the four schools with which it had the greatest catchment overlap. They argued that the unit of analysis must be the local markets within which schools and parents actually operate. Polarisation is likely to be hidden at higher spatial scales.

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[5] See equation (1), where the GS index is shown to be simply related to the KM index which incorporates the overall FSM share.

Taylor et al (2003) undertook case studies of four schools and computed segregation ratios for each at different spatial scales, including competition space(s) which were defined in an ad hoc manner. The time trends for each school's segregation ratio were generally consistent across these different scales. The authors recognise the inappropriateness of defining a mutually exclusive competition space for each group of schools, given the likelihood of linked competition which implies overlapping spaces.[6]

In an investigation of patterns of ethnic polarisation in schools, Harris and Johnston (2008) develop a spatial algorithm to identify a core catchment area (CCA) for each primary school in Birmingham based on 50% (75%) of its enrolments. Inferences are drawn about whether residential segregation within the CCA drives school segregation, or whether significant recruitment of ethnic cohorts occurs outside the CCA. The influence of competing school(s) with overlapping CCA(s) is also analysed.

Harris (2011) develops a local spatial segregation index, LID_i, in which the FSM share of total enrolments in secondary school i is contrasted with the weighted sum of these shares for competing secondary schools.

$$LID_i = \left| p_i - \sum_{j \neq i} w_{ij} p_j \right|, \qquad 0 < w_{ij} < 1, \quad \sum_j w_{ij} = 1, \tag{7}$$

where $\mathbf{W} = [w_{ij}]$ denotes a spatial weight matrix; w_{ij} is determined by the extent to which secondary schools i and j select new pupils from the same primary schools, thereby signifying competition between them:

$$w_{ij} = \sum_k \left(\frac{P_{ki}}{T_i} \right) \left(\frac{P_{kj}}{T_j} \right), \tag{8}$$

where P_{ki} denotes the number of pupils at secondary school i who completed primary education in school k (Harris, 2011). $\mathbf{W}$ is normalised, so that each row sum is unity.[7]

This is an innovative way to address the ambiguity of the spatial scale of school segregation, but two specific issues arise, in addition to the inevitability of changing w_{ij} over time. First, secondary schools with pupils from the same primary school are not necessarily in competition, because these pupils could reside on opposite sides of the primary school and the two secondary schools could be located even further apart and not have overlapping CCAs.

Second, the definition of the w_{ij} introduces a bias to index computations because, if a selective school chooses not to accept pupils from a primary school which services a community with low socioeconomic status and academic achievement, then the competitive relationship between this school and other secondary schools which accept pupils from this primary school will be weakened which will distort the LID value.

So this measure potentially ignores the issue of proximity and also air brushes the entry criteria of particular secondary schools out of the segregation measure. This would seem to be inconsistent with the original objective of measuring UK school segregation: namely, to gauge the impact of legislative reform.

A better approach, which draws on the work of Gibson and Asthana (2000), would be to calculate spatial weights, w_{ij}, for all schools i and j, based on the extent of overlap of their respective (75%) CCAs devised by Harris and Johnston (2008) (or Singleton et al, 2011) to

avoid outliers. This allows overlapping markets and addresses the concerns of Taylor et al (2003, page 58) about the construction of mutually exclusive markets. Now an amended, multigroup version of Harris's LID index could be adopted of the form

$$\text{LĨD}_i = 0.5 \sum_k \left| p_i^k - \sum_{j \neq i} w_{ij} p_j^k \right|, \qquad 0 < w_{ij} < 1, \quad \sum_j w_{ij} = 1, \tag{9}$$

where k denotes the ethnic group and p_j^k denotes the share of enrolments in school j of ethnic group k.[8]

Conclusion

The original motivation for index measurement was to identify the impact of marketisation on socioeconomic segregation within UK secondary schools following the 1988 legislation (Gorard and Fitz, 1998). Further legislative change has followed, but the research objective remains unchanged.

This paper has confirmed that the GS index in concert with the FSM classification of pupils is not fit for purpose, both due to the structural characteristics of school segregation and because no aspatial index can address the inherently spatial features of school segregation.

If entry criteria impose significant constraints on the school choices of certain groups, then this should be revealed by the measure of segregation, rather than being finessed. Thus the extent of meaningful competition between schools for pupils should be measured by reference to proximity (cf Harris, 2011; 2012). The degree of overlap between the CCAs of different schools, which underpins the adjusted LID index, is a crude proxy for the degree of bilateral (or trilateral ...) competition between them, given that the schools are accessible by public or private transport. However, spatial sorting via 'mortgage by postcode' cannot be corrected for.

Cross-section comparisons of schools' levels of segregation are largely meaningless, given their own heterogeneity and that of their neighbourhoods. Time-series index comparisons would be more meaningful if margin dependence were addressed via the DS data transformation, but then artifactual structural issues associated with the dynamic economic and educational environments would come into play, in addition to the ever-changing weight matrix. So, the warning from Johnston and Jones (2010, page 1269) that "[I]f you want to use an index—caveat emptor" remains apposite.

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[8] Empirical papers on US segregation by ethnic group at multiple geographical levels by Reardon et al (2000) and Frankel and Volij (2011) exploit the decomposability properties of the Theil and the Mutual information indexes, respectively, but the computed measures can only be meaningfully interpreted if the underlying spatial unit, namely school districts are largely self-contained with respect to students' travel to school.

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