What Should an Index of School Segregation Measure?

by

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Abstract

The article aims to make a methodological contribution to the education segregation literature, providing a critique of previous measures of segregation used in the literature, as well as suggesting an alternative approach to measuring segregation. Specifically, the paper examines Gorard *et al.*'s (2000a, 2003) finding that social segregation between schools, as measured by free school meals (FSM) entitlement, fell significantly in the years following the 1988 Education Reform Act. Using Annual Schools Census data from 1989 to 2004, the paper challenges the magnitude of their findings, suggesting that the method used by Gorard *et al.* seriously overstates the size of the fall in segregation. We make the case for a segregation curve approach to measuring segregation, where comparisons of the level of segregation are possible regardless of the percentage FSM eligibility. Using this approach, we develop a new method for describing both the level and the location of school segregation.

1. Introduction

It is important for policy makers and researchers to know how socially segregated our schools are, yet researchers still disagree on how to measure segregation. Measuring and trying to understand the reasons for changes in school segregation in England is central to the evaluation of policies designed to increase choice and competition both in and since the 1988 Education Reform Act (see Whitty *et al.*, 1998). Sociologists have argued that these policies would have unintended consequences in terms of stratification of different types of pupils across schools. The central hypothesis is that greater school choice will lead to parents/pupils from higher socio-economic groups being more successful than those from lower socio-economic groups in choosing the higher performing schools. This in turn will cause these high performing schools to improve still further due to positive peer effects from their advantaged intake. This so called virtuous cycle will, it is suggested, lead to increasing polarisation between schools in terms of the ability and socio-economic background of their intakes (Bourdieu, 1997; Bowe *et al.*, 1994; Halsted, 1994).

Whether this increased polarisation is actually happening is an empirical question and a sizeable body of evidence has been accumulated. A number of qualitative and smaller scale quantitative studies have suggested that there has been increasing polarisation between schools. However, in the late 1990s, a major research programme using large-scale longitudinal quantitative data, suggested that the opposite had happened in England and Wales following the 1988 Act (Gorard, 1997, 1999, 2000; Gorard & Fitz, 1998, 2000a, 2000b; Gorard & Taylor, 2002a; Gorard *et al.*, 2002). Using quantitative data on the distribution of pupils taking/eligible for free school meals (FSM) across all schools in the 1990s, the results from this work suggested that, contrary to most theoretical predictions, schools in England and Wales actually became less socially segregated in the 1990s. Figure 1 illustrates the level of segregation in the years 1989 to 1999, as measured by Gorard's Segregation Index (GS) and reported in Gorard *et al.* (2003).

Insert figure 1 about here

This was a controversial finding, given that it contradicted the evidence from previous (generally smaller scale) studies. Gorard, Taylor and Fitz's work then spawned a vigorous debate that continues unabated (Gibson & Asthana, 2000, 2002; Goldstein & Noden, 2003; Gorard, 2002; Gorard, 2004; Noden, 2000, 2002).

Arguments about how best to measure segregation combine normative disagreements about what segregation actually is with technical arguments about the desirable properties of a segregation index. The normative debate is important as it guides us as to the relative importance of the different technical features of any given index.

This paper aims to provide an explicit critique of the GS index, proposing an alternative approach to measuring segregation. We conclude that whilst the findings of Gorard *et al.* do hold regardless of measure used, the GS is not the optimal measure for making inferences regarding changes in social segregation in schools. This is an important contribution, given the extensive use of the GS index in research on school segregation (e.g. Gorard & Smith, 2004; Gorard *et al.*, 2003; Taylor *et al.*, 2005). We make a case for adopting indices that are consistent with the segregation curve, such as the index of dissimilarity or Hutchen's Square Root index.

The rest of the paper is set out as follows. We end this section by giving an overview of the data used and a summary of the segregation indices discussed in this article. Section 2 provides a normative discussion of the term segregation, along with a more technical account of the principles of segregation measurement. The section introduces the segregation curve and the index of dissimilarity (D) as one summary statistic of this curve. Section 3 describes Gorard *et al.*'s alternative index (the GS) and highlights its key features. Section 4 uses Annual Schools Census data to illustrate the extent to which the GS index provides a different pattern of changes in school segregation between 1989 and 1995 onwards, as compared to alternative measures of segregation such as the dissimilarity index. It also provides some current empirical evidence on the extent and nature of segregation in England. Section 5 concludes.

1.1 Data and Summary of Segregation Indices

Data used throughout this article comes from the Annual Schools Census of English secondary schools between 1989 and 2004. Data from between 1989 and 1995 is used to replicate and further analyse Gorard *et al.*'s original findings. It uses data based on local education authority (LEA) boundaries from before the Local Government reforms. Data from between 1999 and 2004 is used to analyse recent changes in school segregation using current LEA boundaries.

The article focuses solely on social segregation between schools, though the analysis could equally be applied to ethnic, gender or other types of segregation. We use a binary indicator for pupils who are either eligible for (after 1993) or in receipt of (pre-1993) free school meals (FSM), using this as a proxy for social disadvantage (the drawback of this categorisation is discussed elsewhere (Croxford, 2000; Shuttleworth, 1995)). Throughout the article, a pupil eligible for free school meals is labelled 'FSM' and a pupil not eligible for free school meals is labelled 'NONFSM'.

Five different segregation indices are used in different parts of this article to discuss the strengths and weaknesses of certain axiomatic properties, introduced in the next section. A summary of these indices is provided here.

Insert table 1 about here

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2. A Good Index of Unevenness Segregation

2.0 Defining segregation

At a general level, segregation is the degree to which two or more groups are separated from each other. In evaluating school choice policies we are particularly interested in whether the distribution of a specific group of pupils across schools in an area has become more uneven; where unevenness is the first of five dimensions of segregation categorised by Massey and Denton (1988).[1] We define unevenness as the extent to which a school's share of FSM and NONFSM pupils deviates from the 'fair share' they would have if FSM and NONFSM pupils were distributed evenly across schools.

Defining segregation as unevenness reduces a remarkably general term (segregation) to a more specific one (unevenness), a step that must be justified. We choose unevenness rather than isolation, for example, because isolation incorporates ideas of both the overall size of the minority group *and* the unevenness in its distribution. So, we argue that because education policy can only influence the latter, unevenness in the distribution of a given minority group between schools is the relevant 'policy lever' for reducing all types of segregation between schools.

2.1 Segregation curves and segregation indices

Two group segregation, such as unevenness in the between school distribution of FSM versus NONFSM pupils, can be graphically illustrated. Segregation curves show this unevenness without the loss of any information and without the need for strong value judgements regarding the exact location of unevenness. Figure 2 shows segregation curves created using actual data for a cohort of year 9 students attending school in

Gloucestershire LEA in 2002/3. The segregation curve is developed by first ranking the schools in order from the school with the lowest proportion of pupils eligible for FSM up to the highest proportion of pupils eligible for FSM, then plotting the cumulative fraction of NONFSM pupils on the x axis and cumulative fraction of FSM pupils on the y axis. The line of equality represents total evenness where every school has its 'fair share' of FSM pupils and NONFSM pupils. Fair share means that if, for example, a school educates 16% of the pupils in an LEA, it will also educate 16% of the FSM pupils and 16% of the NONFSM pupils in the LEA.

Insert figure 2 about here

Using segregation curves we can always identify whether one distribution of pupils is more uneven than another, as long as the two segregation curves in question do not intersect. However, where curves cross, value judgements are required in order to produce a complete ranking of segregation between, for example, different areas or different points in time (Hutchens, 2004). The purpose of unevenness segregation indices is therefore to produce a complete and unique rank ordering of segregation curves by area/time, in essence summarising the extent of segregation across schools in a single numerical value.

There are a set of segregation indices that are solely a function of the segregation curve, which means that if the segregation curve lies on the line of equality, the value of the index is by definition zero; if the segregation curve traces the x axis because all FSM pupils are concentrated in one school, the value of the index should be one. Importantly, the value of these segregation curve approach indices must, by definition, be lower for one segregation curve where it is both closer to the line of equality at all places and does not intersect with the other segregation curve. So, for example in Figure 3, because segregation curves I and II are non-overlapping, all segregation curve approach indices must place a higher value on the segregation relating to curve II compared to curve I.

Insert figure 3 about here

The segregation curve approach to indices is well-established (e.g. Cortese *et al.*, 1976; Duncan & Duncan, 1955; Massey & Denton, 1988) precisely because the value of an index developed under this method is easily interpretable. Segregation curve approach indices are known as relative indices because the level of segregation is always measured, not in an absolute sense, but *relative* to zero (complete evenness) and one (complete segregation), regardless of the relative size of the FSM and NONFSM groups. It is certainly not the only approach in the literature, but we argue that it is the most appealing in this context. It allows measurement of the relative level of segregation in any situation, is axiomatically well-grounded (as shown in the next section) and has been shown to be the logical equivalent of the Lorenz curve approach in the inequality literature (Hutchens, 1991).

2.2 Index of dissimilarity

Continuing the segregation curve approach, this section introduces the index of dissimilarity (known as 'D' from now on), which is the most popular index of unevenness segregation following the review of indices by Duncan & Duncan (1955). D measures the ‘dissimilarity’ in the distribution of FSM pupils across schools from the distribution of NONFSM pupils across schools, is solely a function of the segregation curve and represents the maximum vertical distance between the segregation curve and the line of equality. In the context of segregation between schools by free-school meal eligibility, measured at LEA level, its formula is:

$$D = \frac{1}{2}\sum_{school}\left|\frac{fsm_{school}}{FSM_{LEA}} - \frac{nonfsm_{school}}{NONFSM_{LEA}}\right| \qquad (1)$$

2.3 Axioms of a good segregation index

There is no ‘perfect’ segregation index: each has different properties and incorporates different value judgements about the nature of segregation. The use of D as the primary measure of unevenness segregation in areas such as occupational gender segregation and residential racial segregation stems from its meeting certain criteria for a good index, i.e. it is 0-1 bounded, is solely a function of the segregation curve and meets a set of generally agreed basic axioms reasonably well. These are adapted from the axioms in Hutchens (2004),[2] but are very similar to those discussed by James & Taeuber (1985). It can be shown that a measure that satisfies these properties will always yield a ranking of segregation consistent with the ranking provided by non-intersecting segregation curves (Hutchens, 1991).

P1. Scale or composition invariance – D is invariant to a proportionate increase in FSM or NONFSM, providing each school’s share of the sub-group (e.g. FSM) remains constant *and* the distribution of the other sub-group (e.g. NONFSM) does not change. This means that if *new* FSM pupils enter an LEA from outside, causing the number of

FSM children to double across the LEA as a whole but the share in each school remains the same, the value of the index will not change.

P2. Symmetry in groups – schools can be relabelled and reordered, yet the value of D remains the same. This means that we are indifferent as to whether school A or school B is more segregated; we are simply interested in measuring the extent of segregation between the two schools.

P3. Principle of transfers – D is *usually* capable of being affected by the movement of one individual from school to school. Intuitively, this means that if a child who is eligible for FSM moves from a school with a small proportion of FSM children to a school with a high proportion of FSM children, then the index will show that segregation has increased. Strictly, D does not meet this principle in its ‘strong form’, meaning it does not distinguish between movements between two schools if both are above, or below, the LEA average FSM proportion. However, it is does capture pupil movements from a school with more than their ‘fair share’ of FSM pupils to a school with less than their ‘fair share’ of FSM pupils (the ‘weak form’).

P4. Organisational equivalence – D is unaffected by changes in the number of sub-areas; for example, if a school is divided into two sub-schools by proportional division, then the value of D will not change.

P5. Symmetry between types - D is symmetric in the sense that pupils with FSM could be substituted for NONFSM pupils and vice versa in the formula to produce an identical value for D. We note that there are indices, used in section 4, that are non-symmetric yet are still 0-1 bounded and solely a function of the segregation curve.

There are other segregation indices that, unlike D, meet the axioms above perfectly; most notably an index proposed by Hutchens (2001, 2004) called the Square Root index. The rationale for using D, despite its violation of the principle of transfers, is two-fold. First, unlike the Square Root index it is familiar to researchers, and the Square Root index tends to display low values where the level of segregation is quite moderate, as is typical in schools. Second, D is closely related to the GS index that we discuss in the next section and therefore seems to be the fairer comparison to GS.

3. GS - the 'Strongly Compositionally Invariant' Index

3.0 Gorard's segregation index (GS)

Stephen Gorard created his own segregation index (known as GS from now on), criticising the appropriateness of D on the basis of a problem they label 'strong compositional variance' (Gorard & Taylor, 2002b). This is distinct from the scale or composition invariance described above (in Proposition P1). D *is* composition invariant in that it will not change value if *new* students entering an LEA causes the number of FSM children to rise but proportionately across all schools, i.e. provided that the shape of the segregation curve remains the same. However, if an event takes place that *switches* existing students' status from NONFSM to FSM (for example, a recession increases overall FSM take-up or the measurement of FSM is changed from take-up to eligibility), the value of D will alter even if all schools retain their existing share of FSM pupils. It does so because this type of event would alter the unevenness in the distribution of NONFSM pupils (Taylor *et al.*, 2000). For Gorard and Taylor (2002b), this was a problem that invalidated D's use in school segregation research where overall FSM proportions tend to vary from year to year because it is possible for pupils to change status from NONFSM to FSM, and vice-versa.

Gorard *et al.* rightly identified that the behaviour of an index in the event of an increase in FSM eligibility is particularly important in the context of educational research. They suggested that 'strong compositional invariance' (SCI) is a desirable feature of an index and developed an alternative segregation index (GS) that aims to measure unevenness, controlling for proportionate switches in student status to FSM. In the next section we question the desirability of this property. Whereas D calculates segregation based on the difference between the FSM share of pupils and NONFSM share of pupils at each school in the LEA, GS calculates segregation based on the difference between the FSM share of pupils and the share of total pupils (N) at each school in the LEA.

GS can actually be calculated by first measuring D and then multiplying D by 1-p, where p is the proportion of FSM pupils in the LEA:

$$GS = \frac{1}{2}\sum_{school}\left|\frac{fsm_{school}}{FSM_{LEA}} - \frac{n_{school}}{N_{LEA}}\right| = D * (1-p) \qquad (2)$$

Where the number of FSM pupils increases by scalar λ and by the same proportion in every school such that $FSM_{LEA}^{time=1} = \lambda FSM_{LEA}^{time=0}$ and $fsm_{school}^{time=1} = \lambda\, fsm_{school}^{time=0}$, GS will remain constant. Equation (2) shows that the distribution of NONFSM pupils is not in the calculation of GS, therefore the GS index ignores the fact that such a scalar increase in the number of FSM pupils will also alter each school's share of NONFSM pupils.

Gorard *et al.* made a strong case that GS was therefore the most appropriate index for measuring changes in social segregation between schools over time:

> *The (Gorard) segregation index is the only index we have encountered which is thus able to separate the overall relative growth of FSM from changes in the distribution of FSM between schools. It is suitably ironic that some commentators in educational research have turned this situation on its head and argued that our index is sensitive to changes in composition, while the decomposed index of isolation (Noden, 2000) or even unscaled percentage point differences (Gibson & Asthana, 2000) are composition invariant. That is how wars start!*
>
> (Taylor *et al.*, 2000)

Though the desire to create an index that can deal with the phenomenon of pupils changing their FSM status was important, GS is a measure of segregation with various features that we suggest renders it less desirable to use in measuring segregation between schools. We are not the first to make many of these arguments: Gibson and Asthana (2000) and Noden (2000) both reanalysed and discussed some apparently undesirable features of GS. Furthermore, as Gorard rightly points out, his index, or close variants on it, has been proposed in the past in other fields. It's most cited appearance was as the 'WE' index (which is actually 2*GS) used in an OECD study of Women and Employment (Moir & Selby Smith, 1979; OECD, 1980). However, the WE index has not been used in the field of occupational gender segregation since the mid-1980s and the findings of the OECD study based on WE have been comprehensively dismissed, for many of the same reasons we discuss below.

3.1 GS is not bounded by 0 and 1

The GS index is calculated by shrinking the dissimilarity index (D) by a factor of (1-p), where p is the overall FSM proportion in the area. The result is that GS is bounded by 0 and (1-p), giving it a variable upper limit[3] so that it can never display a value above (1-p). It seems desirable that any index has clear fixed limits, and the convention is that these are 0 and 1. This is a attractive feature because the meaning of complete segregation and complete integration is something that all researchers can agree on, so it seems logical that these should display fixed values of 0 and 1. The value of an index in any particular year or area can only have *relative* meaning with respect to the distance of the value from the boundaries of the index. Where the maximum value is varying according to the overall FSM proportion, the range will not be standard in each situation being compared. This means the value of the index cannot be standard either.

Following the argument of Blackburn *et al.* (1993) in their criticism of WE index, we say that it is not possible to directly compare two values of GS that come from indices with differing boundaries. This will always be the case where the comparison groups have different overall FSM eligibility, which ironically is the precise situation for which the GS was suggested. As an illustration, in England the FSM proportion rose from 8% in 1989 to 16% in 1993. GS is therefore bounded by 0 and 0.92 in 1989, but 0 and 0.84 in 1993. The value of GS fell in this period from 0.35 to 0.32, and the GS would describe this as a fall in segregation: indeed the value of GS is nearer to evenness (0). However, because the upper bound of the index has also fallen, segregation could also be described as being closer to total segregation, as illustrated in Figure 4.

Insert figure 4 about here

The implication of the variable upper bound is that when using GS, segregation is always relatively low in areas of high FSM eligibility, even if all the NONFSM pupils are concentrated in one school. We argue that this view of the costs of segregation is an undesirable one. It implies that the range of possible effects of segregation is smaller where 90% of pupils are FSM eligible (maximum value of GS = 0.1), compared to a situation where, say, 5% of pupils are FSM eligible (maximum value of GS = 0.95). In schools data, GS would indicate that segregation in Tower Hamlets (GS = 0.11 with a maximum value of 0.40 because p=60%) could never be higher than current levels in Buckinghamshire (GS = 0.48 with a maximum value of 0.94), even if Tower Hamlets schools became completely segregated. It is therefore not clear how we can use GS to evaluate segregation in these two areas in relation to each other. We argue that since we understand so little about the relationship between school segregation and social welfare, this supports the case for using a 0-1 bounded relative index. Interpretation of segregation indices is clearly always complex, but at least where an index is bounded by 0 and 1 it is 'fair' in that all LEAs have the 'opportunity' to be more or less segregated than one another.

We do, however, recognise that the absolute value of GS does have a specific meaning and Cortese *et al.* (1976) suggest that it could be used as one *indicator* of the 'displacement' caused by segregation, which might aid interpretation of D. Once D is calculated, GS or D*(1-p) is the proportion of FSM pupils that would have to exchange schools in order to achieve evenness. D*p is the proportion of NONFSM pupils that must exchange schools to achieve evenness and D*2p(1-p) is the proportion of all pupils that would have to exchange schools to achieve evenness.[4]

3.2 GS is not symmetric

It is well recognised that one cannot switch the 'labels' on the FSM and NONFSM pupils and get the same value of GS, i.e. that GS is not symmetric. So, for example, the groups of schools in Figure 5 and Figure 6 will have different values of GS even though from an evenness perspective they could be described as identical mirror images of each other. We do not argue that symmetry is always a desirable feature of an index; indeed, we exploit the non-symmetry of other indices later in this article. However, where indices are not symmetric, interpretation becomes more difficult. If FSM pupils are separated from NONFSM pupils, NONFSM are also separated from FSM pupils, and this implies a symmetrical relationship (Blackburn *et al.*, 1993). Where an index is not symmetric there exists two values for the index, and movements in the values may be contradictory (Karmel & MacLachlan, 1988). For example, how can we interpret a situation where segregation is said to be falling for FSM pupils, yet rising for NONFSM pupils? According to GS, this was the case, for example, in Poole LEA between 1999 and 2004, where GS_{FSM} rose by 10% while GS_{NONFSM} fell by 27%. In fact, between 1999 and 2004, GS_{FSM} and GS_{NONFSM} disagreed about whether segregation was falling or rising in half of all LEAs.

In the case of segregation of FSM versus NONFSM pupils, it may be the effect of segregation of FSM pupils that is of interest to us. However this is a normative judgement, and in any case using a non-symmetric index does not mean we are placing a greater weight on the welfare of the minority group, rather than the welfare of all pupils. Indeed, as we have already shown, GS has systematically low values in areas of high deprivation.

Insert figures 5 and 6 about here

3.3 The Undesirability of 'Strong Composition Invariance' (SCI)

Gorard *et al.* argue an index should remain constant if pupils switch their status from NONFSM to FSM in such a manner that $fsm_1=\lambda fsm_0$ in every school in the LEA, allowing all schools to retain their existing shares of FSM pupils as the overall FSM proportion rises or falls. Where an index meets this requirement it can be said to be 'strongly composition invariant' (SCI). The SCI property means GS would not change in these circumstances, yet because a group of pupils have lost their NONFSM status, this event will change the distribution of NONFSM pupils across schools. In fact, the nature of the constant proportionate increase in FSM means that the probability that a NONFSM child switches to FSM status is higher in schools with the highest FSM proportion. Therefore, these (already deprived) schools lose the greatest share of their NONFSM pupils, thus increasing the unevenness of the distribution of NONFSM pupils.[5]

When pupils switch status from NONFSM to FSM, as they did between 1992 and 1993 because we changed the measurement of FSM from take-up to eligibility, there is no reason to presume that the nature of this increase will be a constant proportionate increase in FSM in each school (and therefore a large increase in the unevenness of the NONFSM pupils). For this most highly stringent and unlikely of cases, GS will indeed remain constant; but in most other cases, including the constant proportionate decrease in NONFSM, GS will actually fall. We therefore assert that GS is not invariant to the change in the FSM measure between 1992 and 1993 because this event did not represent a constant proportion increase in FSM at each school, and so it can therefore draw no conclusions about the change in segregation over this time period.

When the SCI property is met, the resulting change in the unevenness of the NONFSM pupils changes the shape of the segregation curve. Thus, no index that has the SCI property can be consistent with the segregation curve approach. Using data for Hackney LEA from the same source as that held by Gorard, the segregation curve in figure 7 provides a graphical illustration of the unevenness in the distribution of FSM and NONFSM pupils in 1989 (using take-up) and 1995 (using eligibility, in line with Gorard's analysis). Since the curves are non-overlapping we can say that unevenness segregation in Hackney rose over these 6 years. However, the value of GS fell from 0.11 in 1989 to 0.10 in 1995 because the downward effect of the increase in overall FSM eligibility on GS outweighed the upward effect of the outward shift in the segregation curve; GS being a function of both. So, the problem of GS incorrectly ranking segregation curves is substantive in schools data. D, which is solely a geometrical function of the segregation curve, rose from 0.14 in 1989 to 0.30 in 1995. GS and D disagree on whether segregation actually fell or rose in an LEA between 1989 and 1995 in 35% of cases.

Insert figure 7 about here

By similar argument, it can also be shown that GS incorrectly ranks segregation curves for two LEAs in any one year. As a result, if we placed LEAs in deciles according to their value of D and GS in 1995, the two indices would disagree about which decile the LEA should be in 63% of cases. This means that the difference in inferences drawn as a result of using D versus GS will be substantial.

D is said to be independent of overall FSM eligibility (p) because it is solely a function of the segregation curve (Duncan & Duncan, 1955). The intuition behind this statement is that the segregation curve plots the shares of FSM pupils on one axis against the shares of the NONFSM pupils on the other. The distribution of these two groups can be treated as independent of each other since no pupil appears in both groups and each axis plots the cumulative distribution from 0% to 100%, regardless of the relative size of the two groups overall. Therefore, no part of drawing a segregation curve relies on knowledge of the value p.[6] Since GS = D*(1-p) and D is known to be solely a function of the segregation curve, GS is a function of the overall FSM proportion (i.e. p) in the area in question. Indeed any index that is 'strongly compositionally invariant', such as GS, *must* partially be a function of the overall FSM proportion, so we can properly describe it as 'composition variant', i.e. it will vary systematically where the overall FSM proportion differs.

4. Re-examining the Empirical Evidence (1989 to 2004)

This section re-examines Gorard *et al.*'s (2003, pages 58-63) presentation of changes in the social composition of schools between 1989 and 1995. It then presents new empirical evidence on the extent and nature of segregation within LEAs between 1999 and 2004, using various segregation curve consistent measures.

4.0 (Un) changing School Segregation from 1989 onwards

Re-analysis of Annual Schools Census data for the years 1989 and 1995 using D indicates that Gorard *et al.* were indeed correct that, nationally, FSM segregation between schools fell during this period. However, by using the GS index with its falling upper bound (as the FSM measure rose) they measured a in fall segregation twice as large as that suggested by D: D (measured nationally using FSM take-up in both years) fell by 5% from 0.292 in 1989 to 0.277 in 1995; GS fell by 10%. The picture in individual LEAs during this period is more balanced: segregation rose in 42% of (the 107 pre-LGR) LEAs; it fell in the remaining 62%. The national fall is shown in figure 8 to demonstrate that the fall in D was highly concentrated in the recession years of 1991 to 1993.

Insert figure 8 about here

Gorard and others have noted that it is unlikely that the substantial fall in the value of the GS index between two consecutive years (it fell 7% between 1991 and 1992) represents genuine changes in segregation caused by choice, as opposed to the impact of the recession. Our sub-unit of analysis is the entire secondary school so it would take five years to completely replace the school population and for the full effect of increased choice to emerge. So, if genuine changes in segregation explained such a substantial fall in the GS index over the two year period, surely segregation would have continued to fall at a similar rate in the following few years; yet it did not.[7]

4.1 Recent changes in social segregation between schools

Over the five year period of 1999 to 2004, the empirical evidence paints a mixed picture of rising social segregation between schools in 60% of LEAs and falling segregation in 40% (see table 2). School segregation has risen fastest in London, with a mean increase in D of 9% over the period. Indeed static or rising segregation is the trend in most regions, although the South East region has seen a dominant trend of falling segregation. However, these regional trends hide inter-LEA differences within regions: even in the

South East 37% of LEAs actually saw a rise in segregation over the period, despite the downward regional trend.

Insert table 2 about here

Identifying the causes of changes in the level of segregation across LEAs is essentially impossible in this dataset. However, one can look at associations between changes in D and LEA characteristics. Our results, consistent with work of other researchers, suggest that school closure continues to be associated with falling segregation. Regression of the percentage change in D between 1999 and 2004 in table 3 confirms this relationship[8].

Table 3 also shows that areas with higher proportions of grammar schools have not generally been associated with falling segregation, but where there has been a growth in the proportion of pupils at grammar schools segregation appears to have fallen. This is consistent with the known correlation between FSM eligibility and ability: as grammar schools expand they accept pupils from lower down the ability spectrum and therefore their FSM share increases (albeit from extremely low levels to very low levels).

Interestingly, areas with a higher proportion of pupils at voluntary-aided faith schools in 1999 have seen greater growth in segregation. Where these VA schools have grown in size, increasing their share of pupils in the LEA, this is again associated with increasing segregation. Once again, it would be unwise to attribute causation of this phenomenon to the behaviour of VA schools.

Insert table 3 about here

4.2 Different Locations of Segregation

Focusing solely on *levels* of segregation may, however, mask different patterns in the distribution of FSM pupils within LEAs. Drawing segregation curves for two LEAs with equal values of D (0.38), such as those in figure 9 illustrates this idea clearly. Lambeth's segregation curve is very steep on the far right hand side of the graph, suggesting a large proportion of low-income pupils are concentrated in one or two schools. Birmingham's segregation curve is very flat on the left hand side of the graph, suggesting a set of schools in the LEA with very few low income pupils. Clearly there are potentially different policy implications for these two different manifestations of the same level of segregation.

Insert figure 9 about here

We use a set of segregation-curve-consistent indices called the Generalized Entropy Measures of Segregation (Hutchens, 2004) to distinguish between these different patterns of FSM pupils in LEAs. The formula for these indices is:

$$O_c \; x = -\sum_{school} \frac{nonfsm_{school}}{NONFSM_{LEA}} \left[\left(\frac{fsm_{school}}{FSM_{LEA}} \Big/ \frac{nonfsm_{school}}{NONFSM_{LEA}} \right)^{c} - 1 \right], \; where \; 0 < c < 1 \qquad (3)$$

Where c = 0.5, the index is symmetrical and is termed the Square Root index; otherwise they are non-symmetrical and it is this feature that allows us to use them to distinguish between LEAs with 'concentrations of disadvantage' as compared to 'concentrations of advantage'. We use a log ratio of the values of $O_{0.1}(x)$ and $O_{0.9}(x)$ (the choice of 0.1 and 0.9 being quite arbitrary) to rank LEAs in terms of their tendency to display 'disadvantaged' versus 'advantaged' segregation, where 0 indicates no skewness, positive values indicate increasing concentrations of advantage and negative values indicate increasing concentrations of disadvantage:

$$segregation\,skew = \log\left(O_{0.1}\ x \big/ O_{0.9}\ x \right) \quad (4)$$

Table 4 shows that English LEAs typically show concentrations of advantage and that these are most pronounced in the West Midlands region. Reading LEA shows the greatest concentration of advantage at +0.71. By contrast, Brighton & Hove LEA shows the greatest tendency towards concentrations of disadvantage. It should be emphasised that the value of the segregation skew does not indicate the absolute level of concentration of disadvantage or advantage, rather the tendency towards a concentration of disadvantage/advantage for any given level of segregation.

Insert table 4 about here

4.3 Describing changes in segregation curves using a set of indices

When the level of segregation changes in an LEA, it is possible to describe quite precisely the nature of this change. Segregation might increase as a result of the school with the most deprived intake increasing its share of FSM pupils further, thereby concentrating disadvantage. Alternatively, segregation might increase if the school with the fewest FSM pupils reduces its share of FSM pupils, thereby concentrating advantage. Using Reading LEA in figure 10 as an example, we suggest that four values can be used to describe both the level and changes in segregation as follows:

(a) the general level of school segregation can be represented by a symmetrical segregation curve approach index, such as D or Hutchen's Square Root index (i.e. $O_{0.5}(x)$). So, for Reading LEA the level of FSM segregation in 1999 was D=0.28, which is higher than the typical LEA (64th highest of 148 LEAs).

(b) the skew of school segregation – concentrations of 'advantage' versus 'disadvantage' – can be measured using $\textit{segregation skew} = \log\left(O_{0.1}(x) \big/ O_{0.9}(x) \right)$. For Reading LEA the skew in 1999 was +0.74, one of the highest in the country (rank 12 of 148).

(c) the increase in school segregation can be represent by the growth in a symmetrical index. For Reading LEA, the growth in FSM segregation between 1999 and 2004 was 2% (lower than the typical LEA).

(d) the location of the change in school segregation, or change in skew, can be measured using a ratio indicating the relative skew in the two years:

$$\Delta \textit{segregation skew} = \log\left[\frac{O_{0.1}\;\; x_{2004} \big/ O_{0.9}\;\; x_{2004}}{O_{0.1}\;\; x_{1999} \big/ O_{0.9}\;\; x_{1999}} \right] \qquad (5)$$

Here a value of 0 indicates that there is no change in the skewness of segregation; a positive value indicates that the increase in segregation is located in the most advantaged schools; a negative value indicates that the increase in segregation is located in the most disadvantaged schools. For Reading LEA the value is -0.03, suggesting that Reading schools where the FSM proportion was already high in 1999 have increased their share of FSM pupils, thus increasing segregation. This is consistent with Figure 10.

Insert figure 10 about here

Figure 11 shows Brighton & Hove LEA had a low level of segregation in 1999 (D = 0.14), but it has risen significantly over the five year period to 2004 (growth = 37%). The skew in the segregation curve suggests concentrations of disadvantage, with one or more schools whose FSM eligibility is significantly above the LEA average (segregation skew = -0.12). This skew towards concentrations of disadvantage has increased (Δ segregation skew = -0.09).

Insert figure 11 about here

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5. Concluding Comments

Gorard and Fitz were the first to use large-scale datasets to challenge the 'crisis account' that school choice would result in increasing social segregation. Using alternative measures, we agree with Gorard *et al.'s* main conclusion that there has been no substantial across the board increase in socio-economic segregation between schools in the majority of LEAs since the Education Reform Act of 1988. However, our methods do generate substantively different results to those produced by Gorard *et al.*. Figures derived from D show a decline that was only half as large as that suggested by GS. Our results also suggest policymakers should not dismiss the potential 'crisis' of rising school segregation. Our evidence suggests rising segregation in many LEAs, particularly in London and in LEAs with high proportions of pupils educated at voluntary-aided schools.

We suggest that the GS index is not the optimal way of measuring changes in school segregation because:

1. GS is not bounded by 0 and 1: the upper boundary varies according to FSM eligibility, so GS is better described as an 'indicator' rather than an index of segregation;

2. GS is not symmetric, meaning that it is capable of showing that FSM segregation is rising and NONFSM segregation is falling simultaneously; and

3. GS is actually systematically variant to changes in overall FSM eligibility, except in the most stringent and unlikely of circumstances. It has a tendency to fall as FSM eligibility rises, regardless of the change in the unevenness of school's shares of FSM and NONFSM pupils.

D and GS are closely related and measure similar aspects of unevenness segregation, but it is substantively important which index is selected. D and GS will only be highly correlated where levels of FSM eligibility do not vary greatly, and this is not the case across schools data. We recognise that the GS index has meaning. It can be used, for example, to count the proportion of FSM pupils that would have to switch schools to achieve evenness. However, in this paper we have made the case for a segregation curve approach to measuring segregation, where comparisons of the level of segregation are possible regardless of the percentage FSM eligibility (p). These indices are 0-1 bounded, thus measuring the *relative* level of segregation compared to complete evenness and complete segregation. Though we have relied on the dissimilarity index for much of this article, we do not claim its superiority over other segregation curve consistent indices. Researchers wanting to take a segregation curve approach should choose the index that aligns most closely with their view of the effects of segregation on social welfare.

We do not want to overstate the case for a segregation curve approach. It cannot separate out the change in segregation due to school choice as compared to processes that change overall FSM eligibility (we take the view that it is not possible to construct an index to do this). It measures the effect of segregation in an area *relative* to the maximum possible effect if pupils were completely segregated, yet we recognise that the effect of segregation on social welfare may differ in areas of high deprivation versus low deprivation. Finally, we recognise that unevenness is not the only dimension of segregation; therefore researchers will continue to use other approaches too.

Deciding how best to measure segregation is complex, combining normative judgements about what one intends to measure, with more technical judgements about the appropriate properties of the chosen measure. We believe we have made a case for a specific approach, being open about the normative judgements we have made to reach our conclusion. We have chosen to criticise one popular alternative approach to measuring segregation, GS. Further research is needed to subject alternative methods, such as multilevel modelling or the isolation index, to the same level of scrutiny.

Notes

[1] The other dimensions being exposure (isolation), concentration (the amount of physical space occupied by the minority group), clustering (the extent to which minority neighbourhoods abut one another), and centralisation (proximity to the centre of the city).

[2] These five principles relate to Hutchen's axioms 1, 2, 3, 4 and 7. Axioms 5 and 6 relate to an ability to aggregate and additively decompose a segregation index; D does not satisfy these axioms.

[3] We define an upper limit as being the value of an index when each school either has only FSM pupils or only NONFSM pupils; and never has a mixture of the two.

[4] Note that 2*p(1-p) is the maximum possible value of the weighted sum of the absolute deviations of the FSM proportion for each school: $\sum_{i=1}^{I} \frac{n_i}{N} \left| p_i - p \right|$, where p_i is the FSM percentage in school i.

[5] In practical terms this actually means that a large constant proportionate increase in FSM is often not achievable because the most deprived school does not have enough NONFSM pupils to lose.

[6] The segregation curve approach is not the only way to demonstrate the independence of the value of D to changes in p: Zoloth (1976) gives a short mathematical decomposition of D's formula to show the same result.

[7] Using FSM take-up, GS is 0.353 in 1991; 0.329 in 1992; 0.308 in 1993; 0.298 in 1994; 0.300 in 1995.

[8] Though we do not discuss it in this article, we recognise that D should only be cautiously used as a dependent variable in a regression for two reasons. First, its use as a dependent variable means that we treat the values of the index as having cardinal meaning, so we would only want to do this where we accepted the linear payoff criterion of D as being appropriate given our view of segregation and social welfare. Second, we recognise that D displays a systematic random allocation bias where the value is non-zero even under random allocation and the extent of the bias depends on various features of each LEA.

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Tables and Figures

Figure 1: Values of Gorard's Segregation Index (GS)

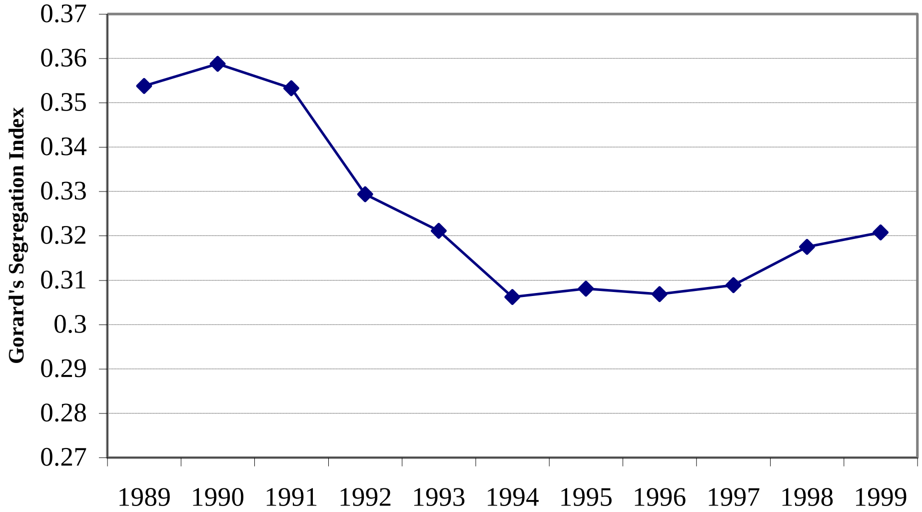


Figure 2: The FSM Segregation Curve for Gloucestershire LEA

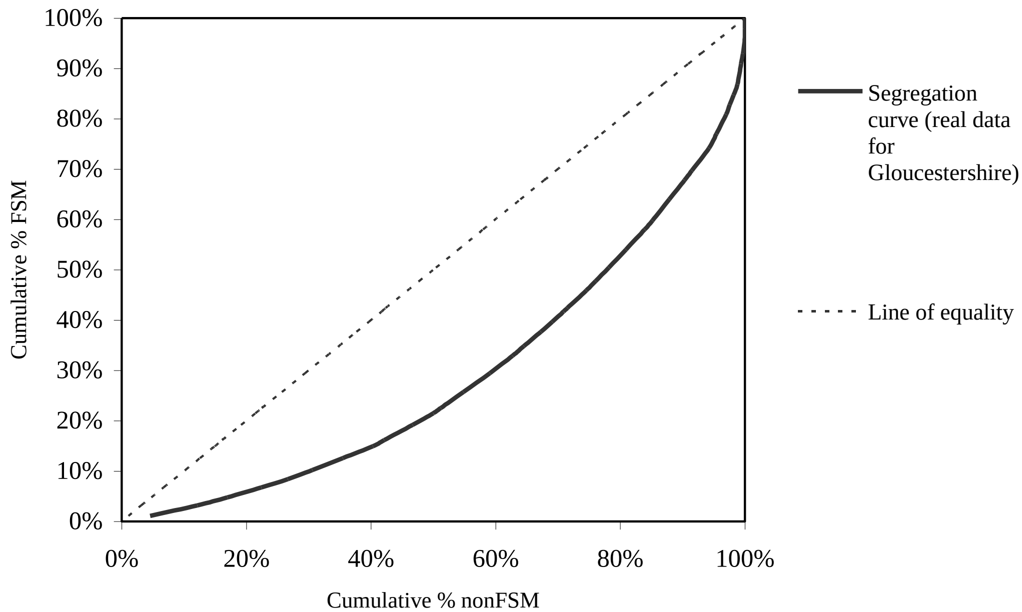


Figure 3: Two Non-Overlapping Segregation Curves

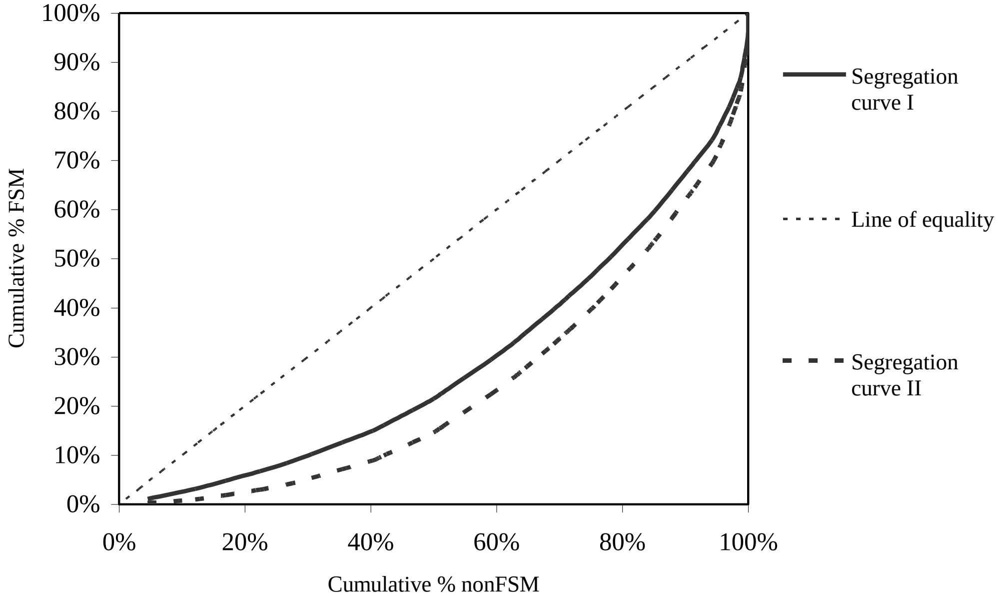


Figure 4: Comparing the Value of Gorard's Segregation Index between 1989 and 1993

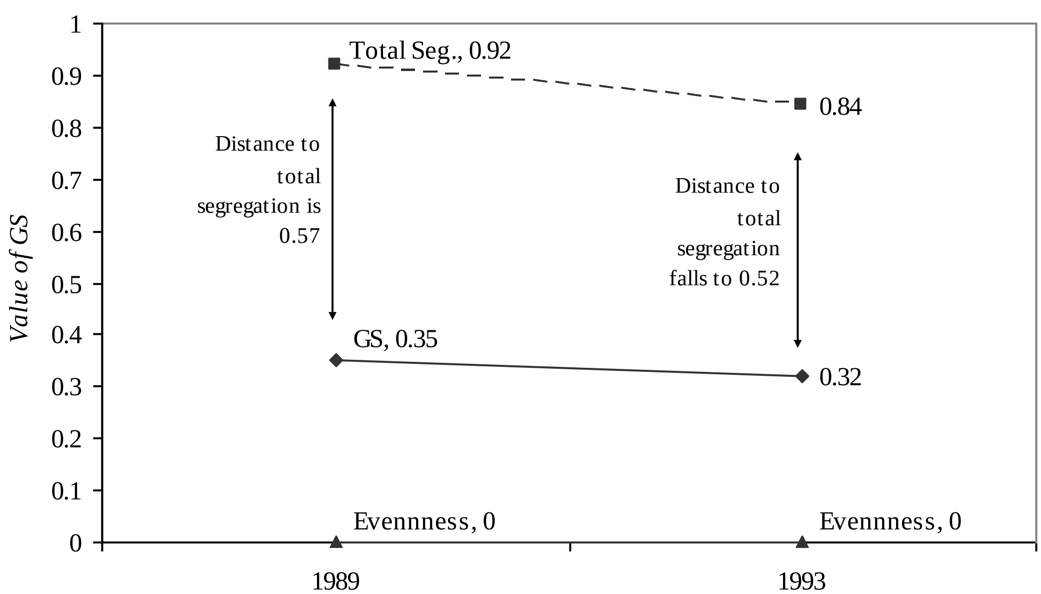


Figure 5: GS is 0.23

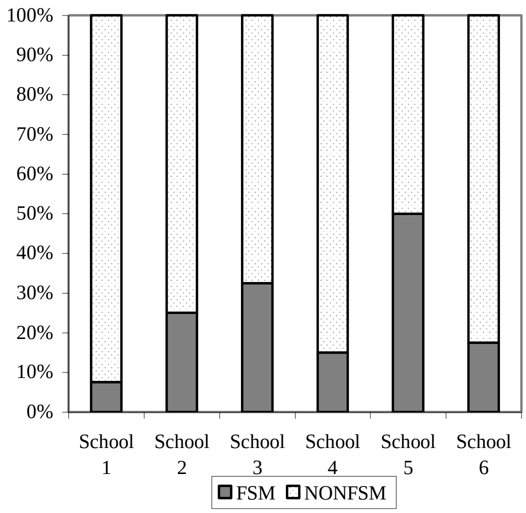


Figure 6: GS is 0.07

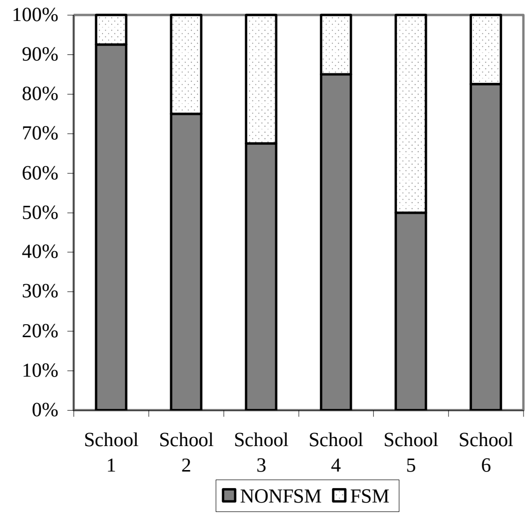


Figure 7: The Rise in Segregation in Hackney between 1989 and 1995

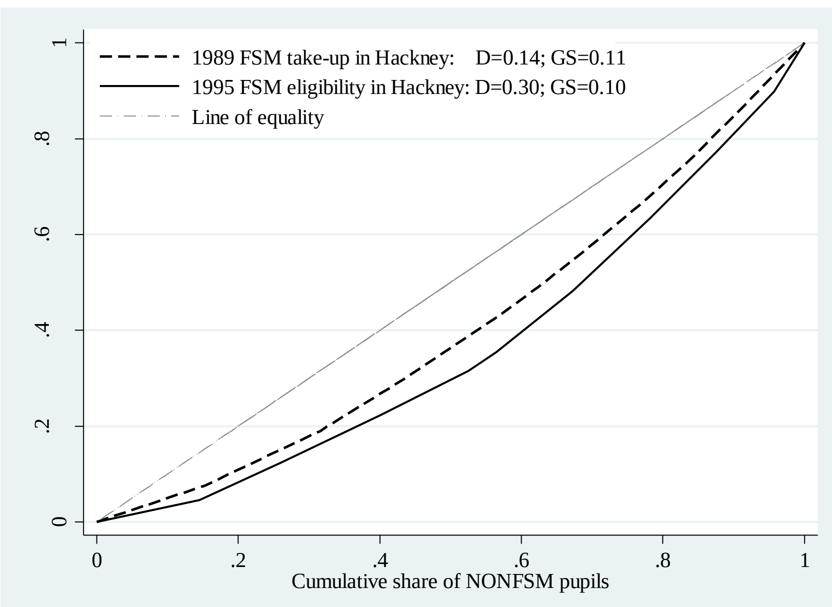


Figure 8: The Fall in School Segregation between 1989 and 1995

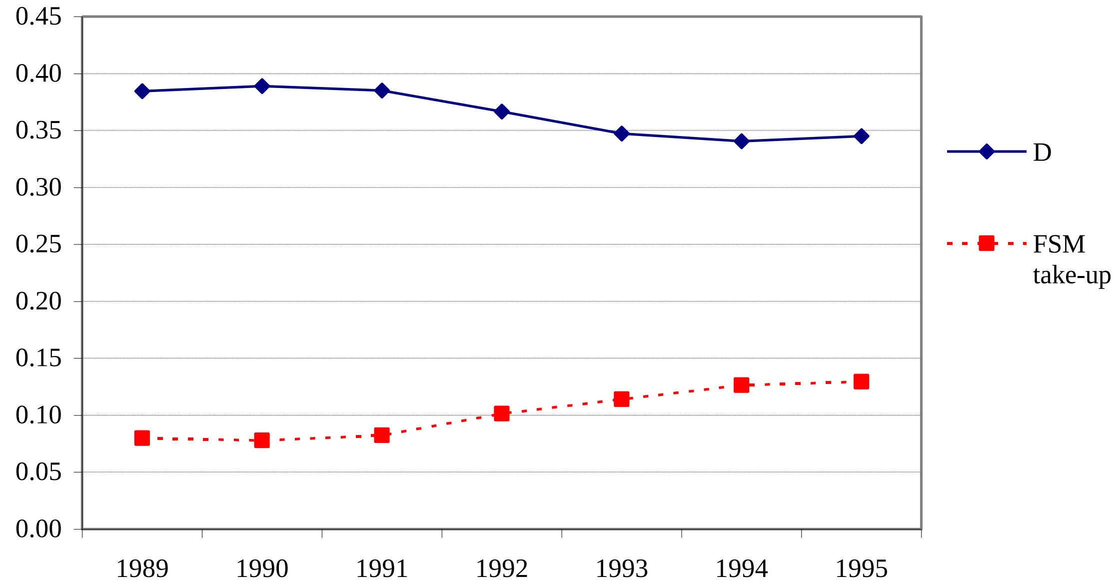


Figure 9: Segregation Curves for Lambeth and Birmingham

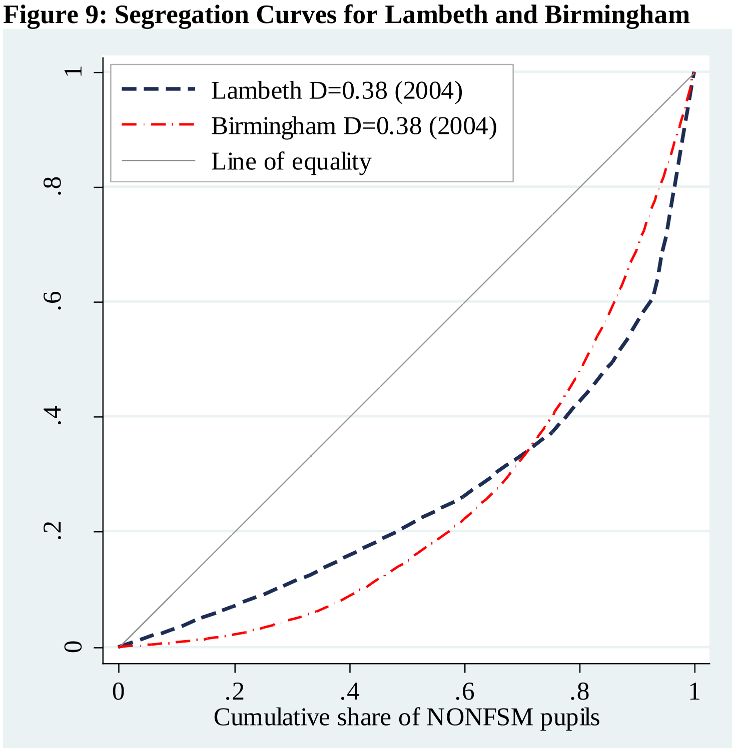
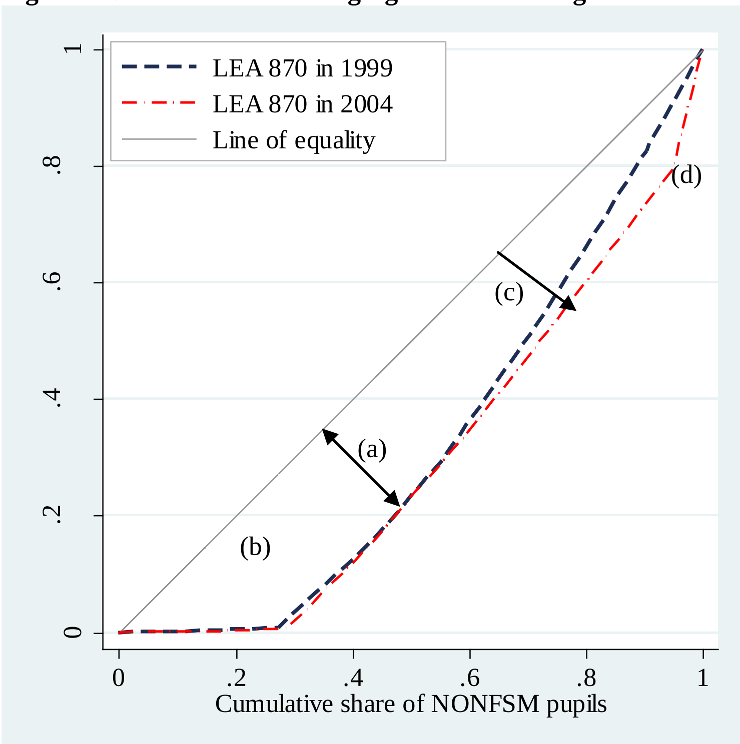


Figure 10: Increase in FSM Segregation in Reading



Below is an alternative version of figure 10. The editor can select the version that is likely to print the best.

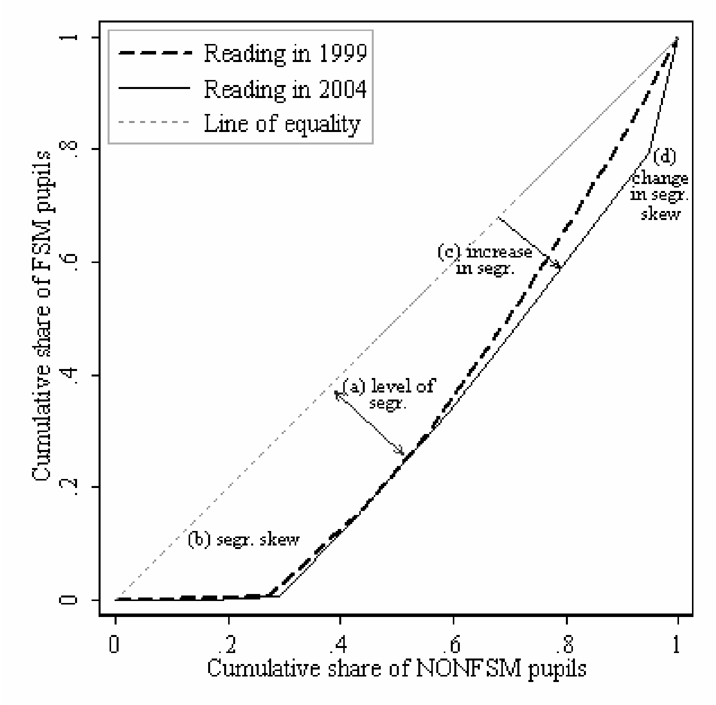


Figure 11: Increase in FSM Segregation in Brighton & Hove

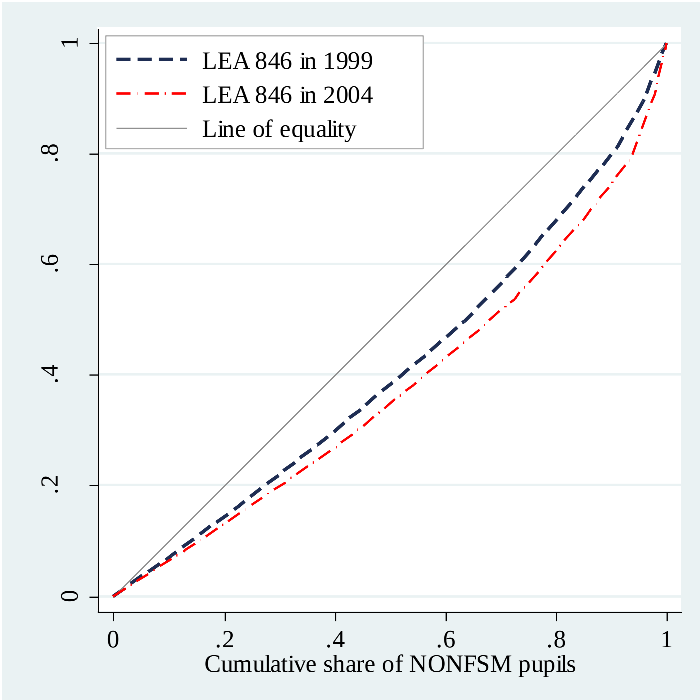


Table 1: Summary of Segregation Indices

Name	Formula	Description	P1. Scale invariance	P2. Symmetry in groups	P3. Principle of Transfers	P4. Organisational equivalence	P5. Symmetry between types
Index of Dissimilarity (D)	$D = \frac{1}{2}\sum_{school}\left\lvert \frac{fsm_{school}}{FSM_{LEA}} - \frac{nonfsm_{school}}{NONFSM_{LEA}} \right\rvert$	**A relative measure of unevenness segregation that compares the FSM share in each school to the NONFSM share in each school.**	✓	✓	✗	✓	✓
Gorard's Segregation Index (GS)	$GS = \frac{1}{2}\sum_{school}\left\lvert \frac{fsm_{school}}{FSM_{LEA}} - \frac{n_{school}}{N_{LEA}} \right\rvert$	**An absolute measure of the proportion of FSM pupils that would have to exchange schools in order to achieve evenness.**	✗	✓	✗	✓	✗
Square Root Index (Generalised Entropy Measure c=0.5)	$O_{0.5}\ x = -\sum_{school}\frac{nonfsm_{school}}{NONFSM_{LEA}}\left[\left(\frac{fsm_{school}/FSM_{LEA}}{nonfsm_{school}/NONFSM_{LEA}}\right)^{0.5} - 1\right]$	**The only fully 'segregation-curve-consistent' and symmetric index, developed by Hutchens (2001, 2004).**	✓	✓	✓	✓	✓
Generalised Entropy Measure of Segregation (c=0.1)	$O_{0.1}\ x = -\sum_{school}\frac{nonfsm_{school}}{NONFSM_{LEA}}\left[\left(\frac{fsm_{school}/FSM_{LEA}}{nonfsm_{school}/NONFSM_{LEA}}\right)^{0.1} - 1\right]$	**A non-symmetric relative measure of unevenness segregation that places a greater weight on schools with 'concentrations of advantage'.**	✓	✓	✓	✓	✗
Generalised Entropy Measure of Segregation (c=0.9)	$O_{0.9}\ x = -\sum_{school}\frac{nonfsm_{school}}{NONFSM_{LEA}}\left[\left(\frac{fsm_{school}/FSM_{LEA}}{nonfsm_{school}/NONFSM_{LEA}}\right)^{0.9} - 1\right]$	**A non-symmetric relative measure of unevenness segregation that places a greater weight on schools with 'concentrations of *dis*advantage'.**	✓	✓	✓	✓	✗

Note: fsm_{school} and $nonfsm_{school}$ are the number of pupils with and without free school meals in a school, respectively.
FSM_{LEA} and $NONFSM_{LEA}$ are the number of pupils with and without free school meals in the LEA, respectively.
n_{school} and N_{LEA} are the number of pupils in the school and LEA, such that $fsm_{school}+nonfsm_{school}=n_{school}$.

Table 2: Changes in LEA segregation between 1999 and 2004

	No. of LEAs	Average change in D	Greatest LEA fall	Greatest LEA rise	% of LEA with higher D in 2004	% of LEA with lower D in 2004
South East	19	-2%	-26%	37%	37%	63%
East of England	10	1%	-16%	13%	70%	30%
East Midlands	9	2%	-15%	10%	56%	44%
West Midlands	14	3%	-20%	27%	50%	50%
Yorkshire & The Humber	15	3%	-19%	24%	60%	40%
England	**148**	**3%**	**-38%**	**58%**	**60%**	**40%**
South West	15	3%	-20%	19%	47%	53%
North East	12	4%	-38%	37%	67%	33%
North West	22	6%	-11%	25%	77%	23%
London	32	9%	-16%	58%	69%	31%

Table 3: Regression of Percentage Change in Segregation 99-04

Number of obs.	148 (weighted for LEA size)		
Adj R-squared	0.26		
Coefficient	**Estimate**	**S.E.**	
Population density	*0.00*	*0.00*	*Not significant*
Dissimilarity in 1999	-0.47	0.16	Significant at 1%
Proportion of pupils at VA schools in 1999	0.24	0.10	Significant at 5%
Proportion of pupils at grammar schools in 1999	*0.10*	*0.11*	*Not significant*
Proportion of pupils at foundation schools in 1999	*0.01*	*0.04*	*Not significant*
Proportion of pupils at CTC/academy schools in 1999	-1.36	0.44	Significant at 1%
Change in number of pupils in LEA	*0.07*	*0.23*	*Not significant*
Change in number of schools	0.32	0.13	Significant at 5%
Change in LEA FSM proportion	*0.08*	*0.10*	*Not significant*
Change in proportion at VA schools	0.12	0.06	Significant at 5%
Change in proportion at grammar schools	-0.36	0.16	Significant at 5%
Change in proportion at foundation schools	*0.14*	*0.12*	*Not significant*
Change in proportion at CTC/academy schools	*0.04*	*0.10*	*Not significant*
Constant	0.13	0.05	Significant at 1%

Table 4: Skewness in the Segregation Curve

Name of Region	No. of LEAs	Mean ratio	LEAs with greatest concentration of disadvantage	LEAs with greatest concentration of advantage
Yorkshire & The Humber	15	+0.01	-0.14 (Rotherham)	+0.17 (Bradford)
East Midlands	9	+0.03	-0.05 (Leicestershire)	+0.13 (Lincolnshire)
East of England	10	+0.04	-0.12 (Bedfordshire)	+0.14 (Peterborough)
North East	12	+0.05	-0.06 (Newcastle)	+0.21 (Stockton-on-Tees)
South West	15	+0.06	-0.13 (Swindon)	+0.22 (Wiltshire)
England	**148**	**+0.07**	**-0.21 (Brighton & Hove)**	**+0.71 (Reading)**
South East	19	+0.07	-0.21 (Brighton & Hove)	+0.71 (Reading)
North West	22	+0.08	-0.08 (Rochdale)	+0.33 (Manchester)
London	32	+0.11	-0.20 (Lambeth)	+0.30 (Westminster)
West Midlands	14	+0.12	-0.05 (Sandwell)	+0.33 (Telford & Wrekin)