Measurement of Segregation by the U.S. Bureau of the Census
in *Racial and Ethnic Residential Segregation in the United States: 1980-2000*
by Weinberg, Iceland, and Steinmetz

BACKGROUND

Residential segregation has been a prominent topic in social science since the great sociologist Ernest Burgess (1928) first published his landmark study on the subject more than 60 years ago. For almost as long, sociologists have argued about how to measure it. The debate has ebbed and flowed, and for a time the issue seemed settled. In 1955, Otis Dudley Duncan and Beverly Duncan published a widely-cited article demonstrating that there was little information contained in any of the then-prevailing indices that was not already captured by the index of dissimilarity. For 20 years thereafter, this measure was employed as the standard index of residential segregation.

This consensus began to unravel in 1976, with the publication of a critique of the dissimilarity index by Charles Cortese and his colleagues. This publication ushered in another period of debate. Over the ensuing decade, a variety of old indices were reintroduced and new ones were invented, yielding a multiplicity of candidates. In an effort to bring some order to the field, Douglas Massey and Nancy Denton in 1988 undertook a systematic analysis of some 19 segregation indices they identified from a review of the extant literature. They argued that segregation is not a unidimensional construct, but encompasses five distinct dimensions of spatial variation.

The five dimensions they identified are: evenness, exposure, clustering, concentration, and centralization. To verify this conceptualization, Massey and Denton carried out a factor analysis of indices computed using 1980 census data for U.S. metropolitan areas Their results showed that each index correlated with one of five factors corresponding to the dimensions they postulated. On theoretical, empirical, and practical grounds, they selected a single "best" indicator for each dimension of segregation. The dimensional structure of segregation, and the Massey and Denton's selection of indices has been reaffirmed using 1990 census data by Massey, White, and Phua (1996). Recently published work by Wilkes and Iceland (2004) suggests this dimensional organization of segregation remains valid for the year 2000.

THE DIMENSIONS OF SEGREGATION

The first dimension of segregation is evenness; it refers to the unequal distribution of social groups across areal units of an urban area. A minority group is segregated if it is unevenly spread across neighborhoods. Evenness is not measured in an absolute sense, but is scaled relative to another group. It is maximized when all areal units have the same relative number of minority and majority members as the city as a whole, and is minimized when minority and majority members share no areas in common.

Among its properties, the index is inflated by random factors when the number of minority members is small relative to the number of areal units (Cortese et al. 1976). It is also insensitive to the redistribution of minority members among areal units with minority

proportions above or below the city's minority proportion (James and Taeuber 1985; White 1986). Only transfers of minority members from areas where they are overrepresented (above the city's minority proportion) to areas where they are under-represented (below the minority proportion) affect the value of the index.

The latter property means that the dissimilarity index fails the "transfers principle," which requires that segregation be lowered whenever minority members move to areas where they are a smaller proportion of the population. This and other problems led David James and Karl Taeuber (1985) to recommend using another measure of evenness, the Atkinson index (Atkinson 1970). Massey and Denton, however, point out that the Atkinson and dissimilarity indices are highly correlated and generally yield the same substantive conclusions. Moreover, the Atkinson index is actually a family of indices, each of which gives a slightly different result, thereby creating problems of comparability. Given that D has been the standard index for more than 30 years, that a large body of findings has accumulated using it, and that the index is easy to compute and interpret, Massey and Denton recommended using it to measure evenness in most cases.

Michael White (1986) points out, however, that another index may be preferred when measuring segregation between multiple groups, since the dissimilarity index is cumbersome to compute and interpret when the number of groups exceeds two. Thus, if one wants to generate an overall measure of segregation between ten ethnic groups, separate dissimilarity indices would have to be computed between all possible pairs of groups and averaged to get a single measure. An alternative index, however, is Theil's (1972) entropy index, which yields a single comprehensive measure of ethnic segregation. The entropy index can also be expanded to measure segregation across two or more variables simultaneously (e.g. ethnicity and income), and can be decomposed into portions attributable to each variable and their interaction (see White 1985; Fischer 2003).

Despite its imperfections, since Duncan and Duncan (1955) the index of dissimilarity has been and remains the most widely-used measure of the evenness dimension and no other index has achieved such widespread acceptance as a summary statistic of segregation.

The second dimension of segregation is exposure, which refers to the degree of potential contact between groups within neighborhoods of a city. Exposure indices measure the extent to which groups must physically confront one another by virtue of sharing a common residential area. For any city, the degree of minority exposure to the majority is defined as the likelihood of sharing a neighborhood in common. Rather than measuring segregation as a departure from some abstract ideal of "evenness," however, exposure indices get at the <u>experience</u> of segregation from the viewpoint of the average person.

Although indices of exposure and evenness are correlated empirically, they are conceptually distinct because the former depend on the relative size of the groups being compared, while the latter do not. Minority members can be evenly distributed among residential areas of a city, but at the same time experience little exposure to majority members if

they comprise a relatively large share of the city. Conversely, if they are a small proportion of the city, minority members tend to experience high levels of exposure to the majority no matter what the level of evenness. Exposure indices take explicit account of such compositional effects in determining the degree of segregation between groups.

The importance of exposure was noted early by Bell (1954), who introduced several indices. However, after 1955 sentiment coalesced around the dissimilarity index and exposure was largely forgotten until Stanley Lieberson reintroduced the P* index in the early 1980s. This index has two basic variants. The interaction index (${}_xP^*_y$) measures the probability that members of group X share a neighborhood with members of group Y, and the isolation index (${}_xP^*_x$) measures the probability that group X members share an area with each other. Both indices vary between zero and one, and give the probability that a randomly drawn X-member shares a neighborhood with a member of group Y (in the case of ${}_xP^*_y$) or with another X member (in the case of ${}_xP^*_x$). Values of ${}_yP^*_x$ and ${}_yP^*_y$ can be computed analogously from equations (2) and (3) simply by switching the x and y subscripts. When there are only two groups, the isolation and interaction indices sum to one, so that ${}_xP^*_y + {}_xP^*_x = 1.0$ and ${}_yP^*_x + {}_yP^*_y = 1.0$. The interaction indices are also asymmetrical; only when X and Y comprise the same proportion of the population does ${}_xP^*_y$ equal ${}_yP^*_x$.

P* indices can be standardized to control for population composition and eliminate the asymmetry (Bell 1954; White 1986). Standardizing the isolation index yields the well-known correlation ratio, or Eta^2 (White 1986). Linda Stearns and John Logan (1986) argue that Eta^2 constitutes an independent dimension of segregation, but Massey and Denton hold that it straddles two dimensions. Being derived from P*, Eta^2 displays some properties associated with an exposure measure; but standardization also gives it the qualities of an evenness index. Massey and Denton demonstrate this duality empirically and argue that it is better to use D and P* as separate measures of evenness and exposure. Nonetheless, Paul Jargowsky (1996) has shown that one version of Eta^2 yields a better and more concise measure of segregation when one wishes to measure segregation between multiple groups simultaneously.

The third dimension of segregation is clustering, or the extent to which areas inhabited by minority members adjoin one another in space. A high degree of clustering implies a residential structure where minority areas are arranged contiguously, creating one large enclave, whereas a low level of clustering means that minority areas are widely scattered around the urban environment, like a checkerboard.

The index of clustering recommended by Massey and Denton is White's (1983) index of spatial proximity, SP. It is constructed by calculating the average distance between members of the same group and the average distance between members of different groups, and then computing a weighted average of these quantities. SP equals one when there is no differential clustering between X and Y, and is greater than one when X-members live nearer to each other than to Y-members. In practice, SP can be converted to a zero-to-one scale by taking the quantity SP-1 (Massey and Denton 1988). White (1984) has also proposed a more complex standardization by taking $f(d_{ij})=d_{ij}^2$, which yields a statistic equivalent to the proportion of spatial

variance explained.

Jakubs (1981) and Morgan (1983a, 1983b) have proposed that D and P* be adjusted to incorporate the effects of clustering. Massey and Denton argued against this procedure because they thought it confounded two different dimensions of segregation. They maintained it is better to measure clustering directly as a separate dimension rather than trying to adjust other measures to reflect it and since 1988 scholars have generally followed this advice.

The fourth dimension of segregation is centralization, or the degree to which a group is located near the center of an urban area. In the postwar period, African Americans became increasingly isolated in older central cities as whites gravitated to suburbs. Centralization is measured by an index that reflects the degree to which a group is spatially distributed close to, or far away from, the central business district (CBD). It compares a group's distribution around the CBD to the distribution of land area around the CBD using a formula adapted from Duncan (1957). Under most circumstances, the centralization index varies between plus one and minus one, with positive values indicating a tendency for group X members to reside close to the city center, and negative values indicating a tendency for them to live in outlying areas. A score of zero means that the group has a uniform distribution throughout the metropolitan area. The index states the proportion of X members who would have to change their area of residence to achieve a uniform distribution around the central business district.

The last dimension of segregation is concentration, or the relative amount of physical space occupied by a minority group in the urban environment. Concentration is a relevant dimension of segregation because discrimination restricts minorities to a small set of neighborhoods that together comprise a small share of the urban environment. The index of concentration takes the average amount of physical space occupied by group X relative to group Y, and compares this quantity to the ratio that would obtain if group X were maximally concentrated and group Y were maximally dispersed.

Under most circumstances, the resulting index varies from minus one to plus one; a score of zero means that the two groups are equally concentrated in urban space, and a score of minus one means that Y's concentration exceeds X's to the maximum extent possible; a score of positive one means the converse. Under certain circumstances, however, Egan, Anderton and Weber (1997) demonstrate that whenever the number of *X* members is very small and the areas in which they live are very large, the index becomes unbounded in the negative direction. Thus, caution should generally be exercised when measuring the concentration of groups with very few members.

MEASUREMENT OF SEGREGATION SINCE 1988

Since Massey and Denton's (1988) analysis, social scientists have generally sought to measure one or more of the five dimensions they identified. In doing so, they have most often employed one of the five indexes they recommended, though in certain applications other indices have been used. Which of these five indices of segregation is chosen for a particular application depends on the purpose of the study. All are valid measures and arguments about which one is "correct" or "best" are meaningless. They measure different facets of segregation. D provides an overall measure of evenness that is highly comparable with prior work, widely understood, readily interpretable, and independent of population composition. P* captures the degree of inter- and intra-group contact likely to be experienced by members of different groups, and it directly incorporates the effect of population composition. Work in the last decade has relied most heavily on these two segregation measures (Massey and Denton, 1993; Frey and Farley, 1994, 1996; Massey and Hajnal, 1995; Peach, 1998). Probably the most widely used alternative used to measure evenness is the entropy index, which has often been used to provide a measure of segregation between multiple social groups simultaneously (see Fischer et al. 2004; Fischer 2003).

Neither D nor P* is inherently spatial, however, and each may be applied to study non-geographic forms of segregation, such as the segregation between men and women across occupations (see Jacobs, 1989). The remaining three dimensions are relevant whenever it is important to know about the physical location of a group in space. If the extent to which group members cluster is important, then SP should be computed; if it is important to know how close to the city center a group has settled, then CE may be calculated; and if the sheer amount of physical space occupied by a group is relevant, then CO is the appropriate index.

The most comprehensive understanding of residential segregation is achieved, however, when all five indices are examined simultaneously. Such a multidimensional approach yields a fuller picture of segregation than can be achieved by using any single index alone. Thus, Massey and Denton (1989) found that blacks in certain U.S. cities were highly segregated on all five dimensions simultaneously, a pattern they called "hypersegregation." Denton (1994) has shown that this pattern not only persisted to 1990, but extended to other metropolitan areas, and Wilkes and Iceland (2004) have documented the same basic trend through the year 2000. By relying primarily on the index of dissimilarity, prior work overlooked this unique aspect of black urban life and understated the severity of black segregation in U.S. cities.

NEW METHODOLOGICAL DEPARTURES

Although the measurement scheme developed by Massey and Denton (1998) continues to reign as the dominant paradigm and all of the indices they recommended continue to be accepted as scientifically valid indices of the five basic dimensions of segregation (see, for example, Alba, Logan, and Stults 2000; Charles 2003; Logan, Stults, and Farley 2004), social scientists have nevertheless continued their efforts to refine the conceptualization of segregation and to develop new measures of the degree to which groups are separated from one another residentially. Two promising new approaches have been developed by Grannis (1998) and Charles and Grusky

(2004).

Grannis (1998) develops a new approach to the measurement of residential segregation by redefining the neighborhood, shifting from census tracts to t-communities, which he defines as people living on streets connected at a tertiary intersection, the crossing of two streets with one lane going in each direction and no divider. He shows that people living in t-communities are much more likely to interact socially than other people living on equally distant streets that do not meet at a t-intersection. While t-communities indeed correspond in a more meaningful fashion to the sociological concept of "neighborhood," they are labor intensive to construct, requiring the construction of schematic street grid maps and their visual inspection. So far, the technique has only been used once, for Los Angeles in 1990. The implementation of the Grannis methodology for a report such as that of Weinberg, Iceland, and Steinmetz (2002) does not seem warranted at this time for two reasons: (1) the units of analysis (the t-communities) are not standard units of census geography, and (2) their creation is too costly to implement for all metropolitan areas in the United States.

A second measure known as the association index was developed by Charles and Grusky (2004) to study occupational segregation. It is a measure of evenness but unlike the index of dissimilarity, the entropy index, or the other measures considered by Massey and Denton (1988), it is unaffected by the number or size of the units, is applicable to measure segregation between multiple groups, and satisfies the transfers principle. It is also easy to calculate and appears to offer promise as a potential measure of segregation. At this point, however, it has not yet been applied to measure the residential segregation of racial and ethnic groups—just gender segregation between men and women across occupational groups. Use of the index of association by the Census Bureau in an official publication is thus unwarranted at this time, and should be delayed until social scientists have attempted to apply it to the study of segregation within metropolitan areas and documented its utility and comparability to other measures of evenness.

REFERENCES

Atkinson, A.B. 1970. "On the Measurement of Inequality." Journal of Economic Theory 2:244-63.

Bell, Wendell. 1954. "A Probability Model for the Measurement of Ecological Segregation." Social Forces 32:357-64.

Burgess, Ernest W. 1928. "Residential Segregation in American Cities." Annals of the American Academy of Political and Social Science 14:105-15.

Charles, Camille Z. 2004. "The Dynamics of Racial Residential Segregation." Annual Review of Sociology 29: 67-207.

Charles, Maria, and David B. Grusky. 2004. Occupational Ghettos: The Worldwide Segregation of Women and Men. Stanford: Stanford University Press.

Cortese, Charles F., R. Frank Falk, and Jack C. Cohen. 1976. "Further Considerations on the Methodological Analysis of Segregation Indices." American Sociological Review 41:630-37.

Denton, Nancy A. 1994. "Are African Americans Still Hypersegregated?" Pp. 49-81 in Residential Apartheid: The American Legacy, edited by Robert D. Bullard, J. Eugene Grigsby III, and Charles Lee. Los Angeles: CAAS Publications, University of California.

Duncan, Otis D. 1957. "The Measurement of Population Distribution." Population Studies 11:27-45.

Duncan, Otis D., and Beverly Duncan. 1955. "A Methodological Analysis of Segregation Indices." American Sociological Review 20:210-17.

Eagan, Karla L., Douglas L. Anderton, and Eleanor Weber. 1998. "Relative Spatial Concentration among Minorities: Addressing Errors in Measurement." Social Forces 76:1115-21.

Fischer, Claude S., Gretchen Stockmayer, Jon Stiles, and Michael Hout. 2004. "Distinguishing the Geographic Levels and Social Dimensions of U.S. Metropolitan Segregation 1960-2000." Demography 41:37-60

Fischer, Mary J. 2003. "The Relative Importance of Income and Race in Determining Residential Outcomes in U.S. Urban Areas 1970-2000." Urban Affairs Review 38:669-96.

Frey, William H., and Reynolds Farley. 1994. "Changes in the Segregation of Whites from

Blacks during the 1980s: Small Steps Toward a More Integrated Society." American Sociological Review 59:23-45.

_____. 1996. "Latino, Asian, and Black Segregation in U.S. Metropolitan Areas: Are Multiethnic Metros Different?" Demography 33:35-50.

Jacobs, Jerry A. 1989. Revolving Doors: Sex Segregation and Women's Careers. Stanford: Stanford University Press.

Jakubs, John F. 1981. "A Distance-Based Segregation Index." Journal of Socio-Economic Planning Sciences 15:129-36.

James, David R., and Karl E. Taeuber. 1985. "Measures of Segregation." Pp. 1-32 in Sociological Methodology 1985, edited by Nancy B. Tuma. San Francisco: Jossey-Bass.

Jargowsky, Paul A. 1996. "Take the Money and Run: Economic Segregation in U.S. Metropolitan Areas." American Sociological Review 61:984-98.

Lieberson, Stanley. 1980. A Piece of the Pie: Blacks and White Immigrants Since 1880. Berkeley and Los Angeles: University of California Press.

_____. 1981. "An Asymmetrical Approach to Segregation." Pp. 61-82 in Ethnic Segregation in Cities, edited by Ceri Peach, Vaughn Robinson, and Susan Smith. London: Croom Helm.

Logan, John R., Brian J. Stults, and Reynolds Farley. 2004. "Segregation of Minorities in the Metropolis." 2004. Demography 41:1-22.

Massey, Douglas S., and Nancy A. Denton. 1988. "The Dimensions of Residential Segregation." Social Forces 67:281-315.

_____. 1989. "Hypersegregation in U.S. Metropolitan Areas: Black and Hispanic Segregation along Five Dimensions." Demography 26:373-93.

_____. 1993. American Apartheid: Segregation and the Making of the Underclass. Cambridge: Harvard University Press.

Massey, Douglas S., and Zoltan Hajnal. 1995. "The Changing Geographic Structure of Black-White Segregation in the United States." Social Science Quarterly 76:527-42.

Massey, Douglas S., Michael J. White, and Voon-Chin Phua. 1996. "The Dimensions of Segregation Revisited." Sociological Methods and Research 25:172-206.

Morgan, Barrie S. 1983a. "An Alternate Approach to the Development of a Distance-Based Measure of Racial Segregation." American Journal of Sociology 88:1237-49.

_____. 1983b. "A Distance-Decay Interaction Index to Measure Residential Segregation." Area 15:211-16.

Peach, Ceri. 1998. “South Asian and Caribbean Ethnic Minority Housing Choice in Britain.” Urban Studies 35:1657-80.

Stearns, Linda B., and John R. Logan. 1986. "Measuring Segregation: Three Dimensions, Three Measures." Urban Affairs Quarterly 22:124-50.

Theil, Henri. 1972. Statistical Decomposition Analysis. Amsterdam: North Holland.

White, Michael J. 1983. "The Measurement of Spatial Segregation." American Journal of Sociology 88:1008-19.

_____. 1984. "Reply to Mitra." American Journal of Sociology 90:189-91.

_____. 1986. "Segregation and Diversity: Measures in Population Distribution." Population Index 52:198-221.

Wilkes, Rima, and John Iceland. 2004. “Hypersegregation in the Twenty-First Century.” Demography 41:23-36.