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Linking Dichotomous Segregation with Multi-group Segregation: Weighted Segregation Ratios in Selected U. S. Metropolitan Areas

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Abstract

The U. S. residential landscape is increasingly multi-racial and multi-ethnic, giving rise to the question of how to compare dichotomous segregation among multiple groups living in the same area. To address the problem in the existing dichotomous approach, which offers no common basis for comparing dichotomous segregation among multiple groups, this paper develops a weighted segregation ratio approach based on Theil's segregation index and its additive decomposability. This approach can be used to bridge information obtained from dichotomous segregation between specific groups (such as black-white and black-Hispanic), and dichotomous segregation between group and non-group (such as white-non-white and black-non-black) in previous studies. We apply both dichotomous and weighted segregation ratio approaches to 1990 and 2000 U. S. census data. Results are interpreted for five selected metropolitan areas as well as for the weighted national average. This new approach yields distinctive findings that portray the complicated process of residential segregation, including the increasing significance of Hispanic segregation and Asian segregation in the decade from 1990 to 2000.

Introduction

The past two decades in the U. S. were notable for an increase in racial and ethnic diversity in metropolitan areas. Never in the course of this country's urban development have people with such diverse racial/ethnic backgrounds lived together in the same metropolitan areas (Alba et al. 1995, Fong & Shibuya 2005). This new demographic landscape poses major challenges to the study of racial/ethnic residential patterns, which has been a major window to the exploration of group relations (Fong & Shibuya 2005, Reardon & Firebaugh 2002, Theil 1972, White et al. 2003).

Most studies of residential segregation have been developed out of concern about black-white segregation, and have focused on explaining the segregation between majority and minority groups. Few have explored the role of segregation between any two groups in multi-group segregation or the role of a specific group in multi-group segregation. Studies based on a pair-wise segregation index do not provide information about overall multi-group

segregation, nor do they determine the contribution of the segregation between two groups to the overall segregation of multiple groups. Although some studies have used Theil's information index (Theil 1972) to address multi-group segregation patterns (Iceland 2004, Reardon & Firebaugh 2002, Reardon et al. 2000, Theil 1972), these applications do not address the way in which dichotomous segregation is related to overall segregation

In this paper, we address multi-group segregation and go further than previous studies to explore the contribution of dichotomous segregation to overall segregation. The types of groups examined include (1) the majority and each minority group (i. e., white-black, white-Hispanic, and white-Asian), (2) two minority groups (i. e., black-Hispanic, black-Asian, Hispanic-Asian), and (3) a specific group from all other groups (i. e., white-non-white, black-non-black, Hispanic-non-Hispanic, and Asian-non-Asian).

We developed the weighted segregation ratio (WSR) to account for the contribution of dichotomous segregation to overall segregation. This method helps link the conventional pair-wise residential segregation literature to the multi-group segregation literature. It takes into the consideration of group size and the diversity level in a metropolitan area. We apply the WSR to five selected metropolitan areas in 1990 and 2000. To the best of our knowledge, this study is the first to examine the relationship of dichotomous segregation to multi-group segregation and to compare the patterns of group pairs.

Our method has generated new findings. Although the white-black and white-Hispanic segregation levels remained similar between 1990 and 2000, the findings based on the WSR suggest that there was a decline in the contribution of the white-black segregation to the overall multi-group segregation, while the contribution of the white-Hispanic segregation increased. In contrast, while the levels of black-Asian segregation declined and Hispanic-Asian segregation remained stable, there was an increase in the contribution of both to the overall segregation. This paper explains how the WSR can advance our understanding of the way in which dichotomous segregation contributes to overall multi-group segregation.

Studies of Racial Residential Segregation

Most of the literature on residential segregation relates to dichotomous segregation (Frey & Farley 1996, Lieberman 1980, Massey & Denton 1987). Research consistently documents a high residential segregation of blacks from whites. Since the 1970s, studies have been extended to include Hispanic and Asian residential segregation. They have found that these two groups are highly segregated from blacks, and that the levels of their segregation from blacks are considerably higher than the levels of their segregation from whites (Alba & Logan 1991, Logan et al. 1996, Massey & Denton 1988a, Massey & Denton 1988b).

Using measures of dichotomous segregation over decades, studies tracking black-white residential segregation between 1980 and 2000 have found that it is declining. In a study of the fifty largest American cities, Charles (2003) showed that the average dissimilarity index for blacks and whites dropped about 10 percentage points between 1980 and 2000, although blacks still retained a higher level of segregation from whites than did other groups. Iceland et al. (2002) used various segregation indexes to show that isolation and clustering levels have been increasing for Hispanics and Asians, but that the dissimilarity levels remain

stable. Logan et al. (2004) suggested that these patterns are largely related to the movement of Hispanics to areas of high black segregation. Recognizing the multi-group context, some researchers have explored the segregation of a specific group from the rest of the population in the same residential area (Frey & Farley 1996). These findings demonstrate the complex dynamics of two-group relationships in a multi-group environment. However, these studies fail to show the extent to which dichotomous segregation contributes to the overall multi-group segregation.

In recent years, there have been important advances beyond the two-group approach to understanding multi-group segregation. Such studies have paid special attention to the relationship between diversity and multi-group segregation. This focus can be traced back to the long tradition of the Chicago School, which argues that higher diversity is related to segregation. Because individuals are more likely to cluster with people of similar background (Berry & Kasarda 1977, Hoyt 1939), various “natural areas” of clustered groups emerge as cities become more diverse. The findings, however, are far from conclusive. For example, Iceland (2004) calculated the diversity index and multi-group segregation index for four major racial/ethnic groups in U. S. metropolitan areas in 1980, 1990 and 2000, and found diversity to be positively correlated with multi-group segregation. On the other hand, Logan et al. (2004) found that diversity had no relationship to segregation, as changes in group segregation between 1990 and 2000 did not relate to the proportions of other groups in the metropolitan area. With a different focus, Fischer et al. (2004) decomposed multi-group segregation by geographic levels and found that the segregation of blacks decreased considerably after 1960. They argued that this finding reflected a higher integration of blacks and more segregation of foreign-born population, largely Asians and Hispanics, in their concentrated metropolitan areas. Despite different findings, these studies seem to suggest that diversity in a geographic area may affect the contribution of the segregation between two groups to the multi-group segregation.

Another line of research emphasizes that in addition to diversity, it is important to consider the significance of group size in the relationship of segregation between two groups to multi-group segregation (Breton 1964, Hawley 1986, Lieberman 1980). As critical mass generates and supports various activities, it becomes the centripetal force to draw in co-ethnic members. Most studies on ethnic communities confirm this point. Studies exploring segregation between two groups show that the size of the groups significantly influences their segregation (Charles 2001, Lieberman 1980, Massey & Denton 1987). This observation is well documented in Lieberman’s study of the changes in black segregation levels from 1890 to 1930. Similarly, using more recent data, Alba & Logan (1991, 1993) found that the segregation level of blacks increases as their size increases. Studies on neighborhood changes repeatedly show that an increase in the black proportion leads to further increase in their representation in neighborhoods (Iceland et al. 2005, Massey & Denton 1990, Rosenbaum & Argeros 2005). A greater representation of a minority group in a community increases the likelihood that its presence will be considered in residential decisions (Lieberman 1980), which may lead to white flight (Farley et al. 1994). In short, these studies have shown the importance of group size in understanding dichotomous and multi-group segregation. However, existing research based on a dichotomous residential segregation index has a critical limitation. The index cannot evaluate how the size and diversity of two

specific groups in a community affect the way in which the two-group segregation contributes to the multi-group segregation.

Weighted Segregation Ratio

Our study has developed the weighted segregation ratio (WSR) to examine the relationship between dichotomous and multi-group residential segregation. A first question is why we need a new tool. To answer the question, in the next section we discuss the limitations of using only the conventional dichotomous segregation index or the overall multi-group segregation index to understand residential segregation in today's multi-racial context. Then we introduce WSR and the procedure for calculating it, and discuss its advantages over conventional methods. In particular, we highlight how WSR considers diversity and group size in understanding segregation among multiple groups.

Limitations of Conventional Methods

There are a number of drawbacks to using the conventional pair-wise segregation index to understand multi-group segregation. First, the dichotomous segregation measures for various groups in a geographic area are not independent. To address the issue of interdependency, Lieberman (1963: Pp. 38–40) suggests that there should be a bound for a pair's dissimilarity index if we know the dissimilarity value for two other pairs in a population of three groups. While the idea of bounds is insightful, their utility declines when the number of groups increases. Second, the comparison of dichotomous segregation indexes is not connected to the overall multi-group segregation. It cannot show how the segregation between two specific groups is related to the multi-group segregation. Finally, although studies have noted possible effects of group size and group diversity on the contribution of dichotomous segregation to the multi-group setting, the dichotomous index does not consider both factors simultaneously.

In recent years, research has addressed multi-group segregation by examining overall multi-group segregation measures such as the generalized dissimilarity index (Sakado 1981) or Theil's multi-group segregation index (Theil 1972). However, these multi-group segregation indexes provide the overall segregation level of all groups, but not the connection between dichotomous segregation measures and the multi-group segregation measure. Nor do they show how the diversity and size of each group are related to the multi-group segregation level.

Defining Weighted Segregation Ratio

The weighted segregation ratio (WSR) shows the contribution of the segregation of two groups to the overall segregation level of all groups in the same area. To calculate WSR, we consider that the multiple group segregation level can be decomposed to a set of dichotomous segregation levels that are interrelated. For example, when we consider the segregation of blacks from other groups, the black-white segregation level should be related to the black-Hispanic and black-Asian segregation levels in the same geographic area. Likewise, when we consider the segregation of an ethnic/racial group from all other groups, the segregation level between blacks and non-blacks is related to the segregation level

between whites and non-whites, Hispanics and non-Hispanics, and Asians and non-Asians. Attempts have been made to address the inter-relationship of various dichotomous segregation pairs, by expressing the total multi-group segregation as the weighted sum of dichotomous segregation measures between each group and the rest of the population, e.g., the "generalized segregation index" (James 1986). However, this approach has been criticized as it still fails to consider fully the dependence among dichotomous components. In addition, we note that the approach cannot consider all possible combinations of dichotomous segregation.

After a comprehensive survey of tools for the study of residential segregation, Reardon and Firebaugh (2002) concluded that of all existing multi-group indexes, Theil's segregation index (H) possesses the property of additive decomposability, which allows for decomposing the multi-group index into independent components of segregation at the sublevels (i. e., dichotomous segregation). In other words, dichotomous segregation can be expressed as an additive component of Theil's H multi-group segregation index. In our extension, it can be demonstrated that the decomposition of the overall multi-group segregation index H can yield non-redundant WSRs for all pair-wise groups (see details in the Appendix). As a result, the WSRs are comparable.

Elements of Weighted Segregation Ratio

The pair-wise WSR is the product of three elements: the ratio of Theil's diversity index for two selected groups to Theil's diversity index for all groups, the ratio of Theil's segregation index for the two groups to Theil's segregation index for all groups, and the proportion of the two groups in the total population being studied. Before formally expressing WSR, we briefly introduce diversity index and multi-group segregation index and its decomposition.

The diversity index measures the diversity level in the geographic area being studied. It synthesizes information about the number of groups and the proportion of each group in the area. Understanding diversity in an area can be viewed as the first step to understanding multi-group segregation. The diversity index E takes the following form (Theil 1972):

$$E = \sum_{m=1}^M p_m (-\ln p_m), \quad (1)$$

where the proportion of a group in an area is p_m and for M groups, $\sum_{m=1}^M p_m = 1$. The $-\ln p_m$ (natural log) is a positive value and increases (at a faster rate) as p_m decreases. When only one group lives in the area, then $E = 0$, the minimum value of E . When multiple groups

have the same proportion ($1/M$), then $E = \sum_{m=1}^M \ln(M)/M = \ln(M)$, the maximum value of E .

¹ A higher score of E indicates greater diversity. Theil's diversity index is applicable for any number of groups.

¹For comparisons across populations with different numbers of groups, we must adjust the natural-log-based E by the factor of $1/$

$\ln(M)$. The normalization replaces the natural log with an M-base logarithm in (1) $E = \sum_{m=1}^M p_m (-\log_M p_m)$, such that the range of E becomes $[0,1]$.

Building on E , Theil's segregation index (H) provides a summary measure of multi-group residential segregation. The index can be expressed as (Theil 1972):

$$H = 1 - \sum_j \frac{t_j}{T} \frac{E_j}{E}, \quad (2)$$

where t_j is the population size of tract j , T is the total population of the metropolitan area, E_j is the diversity index of tract j , and E is the metropolitan diversity index. When the tract

diversity is the same as the metropolitan diversity, $H = 1 - \sum_j \frac{t_j}{T} = 0$. When multiple groups are completely segregated, a single group lives in each tract, so the tract diversity is zero, $E_j = 0$, and we have $H = 1 - 0 = 1$. Thus, the range of the segregation index H is $[0, 1]$. The larger the value of H , the greater is the degree of segregation. The segregation index can be interpreted as the weighted sum of deviations of the tract diversity from the metropolitan diversity. Theil's segregation index is flexible for any number of groups because the diversity measure has taken that information into account.

With additive decomposability, the decomposition of the multi-group segregation index gives additive, independent components. To illustrate the group decomposition, we take the simplest situation where the population in an area consists of three groups: X, Y, Z . We divide these three groups into two mutually exclusive groups by combining any two groups, e.g., $X + Y$, to form a “supergroup,” a term used by Reardon and Firebaugh (2002), and let the third group, in this case Z , be another “supergroup.” The decomposition takes the following form (Reardon et al. 2000):

$$H_{\text{total}} = \frac{E_{(X+Y),Z}}{E_{\text{total}}} H_{(X+Y),Z} + p_{X+Y} \frac{E_{X,Y}}{E_{\text{total}}} H_{X,Y} + 0, \quad (3)$$

where p_{X+Y} is the proportion of the population of X and Y combined, and the dichotomous diversity and segregation are based on the population of only X and Y . Letting N indicate the population size, the dichotomous diversity index is

$$E_{X,Y} = \frac{N_X}{N_{X+Y}} \left(-\ln \left(\frac{N_X}{N_{X+Y}} \right) \right) + \frac{N_Y}{N_{X+Y}} \left(-\ln \left(\frac{N_Y}{N_{X+Y}} \right) \right), \text{ and the dichotomous}$$

segregation index is $H_{X,Y} = 1 - \sum_j \frac{t_j}{T} \frac{E_{X,Y,j}}{E_{X,Y}}$.

The first term on the right side of Equation (3) is the “between” component (i. e., between ‘ $x + y$ ’ and z). It is a product of (a) the ratio of the supergroup diversity (i. e., ‘ $x + y$ ’ and z) to the total diversity and (b) the supergroup segregation (i. e., between ‘ $x + y$ ’ and z), which can be viewed as the “group” and “non-group” dichotomous segregation score. The second term is a “within” component (i. e., x and y) of the multi-group segregation index. It is a product of (a) the proportion of the population in the supergroup $X + Y$, (b) the ratio of the X and Y diversity to the total diversity, and (c) the dichotomous segregation between X and Y . The third term is the “within” component of the other supergroup, Z . It is zero, as no segregation exists within a single group.

The first term on the right side of Equation (3), i. e., the “between” component, ‘X+Y’ and Z, can be interpreted as the amount of the total segregation that would be reduced if the segregation of ‘X+Y’ and Z were eliminated while keeping the second component (i. e., the “within” component) unchanged. The “within” component (X and Y) is the amount of the total segregation that would be reduced if the segregation of X and Y were eliminated while keeping the first term unchanged.

Dividing both sides of Equation (3) by H_{total} , the second term becomes the WSR for X and Y denoted by $WSR_{X,Y}$.

$$WSR_{X,Y} = \left(p_{X+Y} \frac{E_{X,Y}}{E_{total}} H_{X,Y} \right) \div H_{total} = \left(p_{X+Y} \frac{E_{X,Y}}{E_{total}} \right) \left(\frac{H_{X,Y}}{H_{total}} \right), \quad (4)$$

and the first term becomes the WSR for Z and (X+Y), denoted by $WSR_{(X+Y),Z}$:

$$WSR_{(X+Y),Z} = \left(\frac{E_{(X+Y),Z}}{E_{total}} H_{(X+Y),Z} \right) \div H_{total} = \left(\frac{E_{(X+Y),Z}}{E_{total}} \right) \left(\frac{H_{(X+Y),Z}}{H_{total}} \right). \quad (5)$$

These two WSRs are between two specific groups and between a group and “non-group”, respectively.

Note that the three-group population consists of three pairs of specific groups and three pairs of group and non-group. Adding the three decompositions, each with a focus on one pair of specific groups within a supergroup, i. e., (X,Y),Z ; (X,Z),Y ; and (Z,Y), X),

$$\begin{aligned} 3H_{total} = & \left[\frac{E_{(X+Y),Z}}{E_{total}} H_{(X+Y),Z} \right. \\ & \left. + p_{X+Y} \frac{E_{X,Y}}{E_{total}} H_{X,Y} \right] \\ & + \left[\frac{E_{(X+Z),Y}}{E_{total}} H_{(X+Z),Y} + p_{X+Z} \frac{E_{X,Z}}{E_{total}} H_{X,Z} \right] \\ & + \left[\frac{E_{(Z+Y),X}}{E_{total}} H_{(Z+Y),X} \right. \\ & \left. + p_{Z+Y} \frac{E_{Z,Y}}{E_{total}} H_{Z,Y} \right] \end{aligned}$$

we arrive at an expression that includes all non-redundant WSRs as follows:

$$3 = WSR_{X,Y} + WSR_{X,Z} + WSR_{Z,Y} + WSR_{(X+Y),Z} + WSR_{(X+Z),Y} + WSR_{(Z+Y),X} \quad (6)$$

Based on Equation (6), we can compare the WSRs for two specific groups or for a group and non-group. The convenience of being able to compare both types of WSR at the same time is true only for a three-group population. When we generalize to M-group populations with $M \geq 3$ (see Appendix for details), it can be shown that only the same groupings of the same type (two specific groups vs. group-non-group) can be compared. Let i or j be a

specific group, $i, j = 1, \dots, M$. The general expression for the first type of WSR is for two specific groups:

$$WSR_{i,j} = \left(p_{i+j} \frac{E_{i,j}}{E_{total}} \right) \left(\frac{H_{i,j}}{H_{total}} \right), i \neq j. \quad (7)$$

The corresponding expression for the second type of WSR is for group and non-group pairs:

$$WSR_{i,rest} = \left(\frac{E_{i,rest}}{E_{total}} \right) \left(\frac{H_{i,rest}}{H_{total}} \right). \quad (8)$$

The first term on the right side of Expressions (7) and (8) is the "weight" in the WSR. It is the product of the proportion for the two groups combined (less than 1 for Expression 7 and equal to 1 for Expression 8) and the ratio of the dichotomous diversity to the total diversity. The second term on the right side is the "segregation ratio" in the WSR. It is the ratio of the dichotomous segregation to the overall multi-group segregation.

Thus, the WSR has three relevant properties. First, WSRs of the same type are additive in relation to the overall multi-group segregation, so we can compare their relative contribution within areas. Second, since E_{total} and H_{total} in the denominator are constant for the same area, the WSR can be considered as standardized and thus comparable not only within areas but also across areas and over time. Third, the WSRs of all exhaustive and non-redundant pairs of groups in a population do not sum to 1 and always sum to less than the number of groups (M) in the population because repeated decomposition is needed, as well as higher-order components exist as the result of decomposition. Related to the third point, we can express the WSR in Expression 7 as the percentage of the overall multi-group segregation using $100 \times WSR/M$ if M is an odd number, or $100 \times WSR/(M-1)$ if M is an even number. The WSR in Expression 8 can be expressed as the percentage of the overall multi-group segregation using $100 \times WSR/M$, regardless of the odd or even number of groups in the population. This quantity is directly comparable for WSRs of the same type. (See the Appendix for a complete account of the WSR for a general population consisting of more than three groups).

In short, the WSR includes information on the segregation, diversity and group size of two groups and allows us to compare them across areas and over time. To illustrate the utility of the WSR, we examine each of the five selected metropolitan areas in 1990 and 2000, compared with the average of all metropolitan areas in the U. S., weighted by their population size.

Data

Our analysis is based on 1990 and 2000 U. S. Census data (SF1 summary files). The segregation index is measured at the census tract level and summarized at the level of the PMSA (primary metropolitan statistical area). While the boundaries of census tracts changed between 1990 and 2000, our examination of metropolitan areas and changes in their segregation patterns over time does not require constant tract boundaries.

The analysis includes five immigrant gateway metropolises: Chicago, Houston, Los Angeles, New York, and San Francisco. Some of them have large proportions of blacks and others have large proportions of Hispanics and Asians. We include four non-Hispanic groups (referred to as white, black, Asian, and other) and one Hispanic group in our analysis.² As individuals were allowed to identify more than one race in the 2000 census, the “other” group includes people of other race/ethnicity or people identifying with two or more races. We also provide the weighted mean of residential segregation. This information provides a context for interpreting the segregation patterns of the five selected metropolitan areas.

Results

We begin our discussion with the composition of racial/ethnic groups (Table 1). We then compare the dichotomous approach and our WSR approach for two types of dichotomous segregation (Tables 2 to 4). We will demonstrate that the dichotomous approach can miss important segregation patterns and trends, whereas the WSR approach offers a way to precisely compare various dichotomous relationships with respect to the total segregation in a multi-group context.

Racial/Ethnic Composition

We begin our analysis by examining the racial/ethnic composition of metropolitan areas in 1990 and 2000 and the changes over the decade. Table 1 shows the proportion of racial/ethnic groups in each of the five selected metropolitan area and the weighted national means of all metropolitan areas in the US in 1990 and 2000. We highlighted some of the major demographic components of these metropolitan areas to provide a backdrop for later discussion of the relationship between two-group segregation and multi-group segregation.

The population composition of each metropolis included in the study is a reflection of the history of development of each city area. Chicago’s population in 1990 included 21.7% non-Hispanic blacks, the only minority group in the metropolis accounting for more than 1.5 times its weighted national mean. This makeup reflects the historical black migration from south to north in the 1940s. Though the black proportion remained high in 2000, it had dropped by 3.1 percentage points (a rate of change of -14.3%). On the other hand, the Hispanic proportion grew rapidly from 12.1% in 1990 to 17.1% in 2000, approaching the proportion of blacks (18.6%).

The population mix in Houston is the consequence of recent decades’ new labor market opportunities attracting diverse racial/ethnic groups, both native-born and foreign-born (Waldinger 1996). The continuation of this development transformed Houston to a more racially diverse area by 2000.

The metropolitan area of Los Angeles expanded quickly after World War II, with its wide sprawl of population linked by highways (Laslett 1996). Disproportionately large numbers

²The narrow definition of Asians from the 2000 census is used, i. e., the “Asian” group does not include Pacific Islanders, Hawaiians, Alaskan natives, or American Indians. Asians include only people of the Far East, Southeast Asia, or the Indian subcontinent.

of Hispanics and Asians resided in Los Angeles, and their proportions continued to grow in the 1990s, largely due to the long history of Mexican immigration and the recent choice of the metropolitan area as a favorite destination of Asians (Grant 2000).

New York has been the most important immigrant-receiving port in North America for centuries, and has become a diverse cosmopolitan area. Like Los Angeles, it has a smaller white population than the other three metropolises in the analysis, and like Chicago, it has a large black population.

San Francisco has a large proportion of Asians, 19.9% in 1990 and 22.5% in 2000, more than five times the national share of the group. The high concentration of Asians can be traced to the long history of Chinese and Japanese immigration to the U. S. (Daniels 1988). In recent decades San Francisco has become a favorite destination of many other Asian groups. There is also a considerable number of Hispanics in the area.

Behind this heterogeneous racial/ethnic composition in the five selected metropolitan areas is a common pattern of a decline in the shares of whites and blacks and a rise in the shares of Hispanics and Asians. This trend is not unique to the five selected areas. The weighted mean proportions of racial/ethnic groups for the nation's metropolitan areas (296 areas in both 1990 and 2000) show a common declining trend in size for whites and a growing trend for Asians and Hispanics. However, the national trend also suggests that the percentage of blacks is rising, which is not the case in the five metropolitan areas selected.

The data clearly show that the growing diversity of racial/ethnic composition in the selected metropolitan areas over the decade from 1990 to 2000 requires a multi-group perspective in examining residential patterns. In the following sections, we explore how residential segregation patterns have unfolded within the context of diversity in these metropolitan areas.

Total Diversity and Multi-group Segregation

The first two columns of Table 2 show the total diversity index (E) and the total multi-group segregation index (H). Results of the total diversity index suggest that all five selected metropolitan areas are more diverse than the national average and that the levels of diversity have increased over time. The pattern reflects the gateway nature of these metropolises, which have become home to large numbers of immigrants from around the world. The level of multi-group segregation among groups in all the selected metropolitan areas except San Francisco is higher than the national average, although it declined in all five areas between 1990 and 2000.

Comparing the total diversity level and the multi-group segregation level, the results at first glance suggest that total diversity does not necessarily relate to total multi-group segregation. Of the five selected areas, Los Angeles and New York are the most diverse, but Chicago and New York are the most segregated. In addition, while the level of diversity in these five metropolises increased, the level of multi-group segregation decreased.

Segregation between Minority and Majority: The Dichotomous Approach

While information about overall multi-group segregation is useful, it remains unclear how segregation between any two groups is related to the overall multi-group segregation. To explore the issue, we first discuss Theil's dichotomous segregation index H (using Equation 4) between a minority group and whites, and then we discuss their WSR, presented in Table 2. Altogether, the information explains the segregation between two groups and its contribution to the overall multi-group segregation.

In Table 2, the dichotomous H columns show patterns similar to those reported in previous studies: The segregation levels of blacks from whites in all five metropolises are higher than those of Asians or Hispanics from whites. For example, blacks maintained a higher level of segregation from whites in Chicago. These findings echo classic works, from Duncan and Duncan (1955), Taeuber and Taeuber (1965), Lieberman (1980), to Massey and Denton (1993), on a high level of black-white segregation in Chicago from 1940 to 1980. The pattern in the five selected metropolises is not unique. The national average of segregation of blacks from whites is higher than that of other groups from whites. The national average of black-white segregation was 0.421 in 1990 and 0.386 in 2000.

Compared to the segregation between blacks and whites, the segregation level of Asians from whites was much lower in both 1990 and 2000, in the selected metropolises and in the national average. The national average of Asian-white segregation was 0.145 in 1990 and 0.142 in 2000. This pattern has also been reported in other studies, suggesting that Asians are able to integrate residentially with whites.

The level of segregation of Hispanics from whites is midway between black-white segregation and Asian-white segregation. The national average was 0.188 in 1990 and 0.216 in 2000. Consistent with the national average, the segregation of Hispanics from whites is higher than that of Asians from whites in four of the five selected metropolises, the exception being San Francisco.

Along with growing diversity and declining multi-group segregation in the 1990s, the segregation levels of blacks and whites declined in all the selected metropolises except New York. As pointed out by Krivo and Kaufmann (1999), growing diversity in a metropolitan area may serve as a buffer from the segregation of blacks and whites. In contrast, Asian segregation from whites increased in all the selected metropolises except Chicago. The increase in Asian segregation in the four metropolises seems to be a reflection of the growth of established Asian communities and economies in these immigrant gateway metropolises (Hagan & Rodriguez 1992, Zhou 1992). Finally, there was an increase in the segregation levels between Hispanics and whites at a national level and in all the included metropolises except Chicago.

In short, the multi-group and dichotomous segregation results provide a complicated picture that is not entirely consistent. On the one hand, there is a general decline in multi-group segregation in all five selected metropolises and in the national average. On the other hand, the dichotomous segregation analysis shows that only the segregation of blacks and whites declined in most of the selected metropolises. There was an increase in the segregation of

whites from both Asians and Hispanics. In addition, the dichotomous segregation index does not provide a means to quantify the contribution of pair-wise segregation to the overall multi-group segregation. To further understand how these dichotomous segregation patterns are related to multi-group segregation, we look at their WSRs in the next section.

Segregation between Minority and Majority: The WSR Approach

To relate the dichotomous segregation between any two specific groups to the multi-group segregation, we calculated the WSR based on Expression 7. We divided the WSR by 5 (i. e., the number of groups in the analysis). The results are recorded in the "WSR as % of Total H" columns in Table 2 (hereafter referred to as WSR). The information reveals certain patterns not captured by the dichotomous H.

The WSR results reveal two major patterns. First, the contribution of black-white segregation to the multi-group segregation in 1990 was much greater than the contributions of Asian-white or Hispanic-white segregation. However, the contribution of black-white segregation was smaller in 2000 than in 1990, while the contributions of both Asian-white and Hispanic-white segregation were larger. In other words, the observed multi-group segregation in 1990 was largely affected by black-white segregation. In 2000, the multi-group segregation was increasingly less affected by black-white segregation, and more affected by Asian-white and Hispanic-white segregation.

Second, the level of dichotomous segregation does not correspond to its contribution to multi-group segregation captured by the WSR, as the WSR measure takes into account the two groups' diversity and size. For example, the Asian-white segregation scores in New York and San Francisco in 2000 are at similar levels: 0. 268 and 0. 260 respectively. However, the contribution of the Asian-white segregation to the multi-group segregation is 2. 5% in New York, and 8. 6% in San Francisco. The latter is over three times the former, because the Asian-white diversity and size are greater in San Francisco than in New York. This finding clearly shows that if only the dichotomous segregation approach is used, it will appear that Asian-white segregation is of equal importance in the segregation landscape of both metropolises. There could be similar misleading findings in Los Angeles if only dichotomous H were used: Black-white segregation (0. 506) has the highest level among the three pairs, yet the contribution of Hispanic-white segregation (10. 8%) is the highest. A similar example can be found in San Francisco where the Asian-white contribution is the highest even though the black-white H is the highest.

Segregation among Minority Groups

The study of multi-group segregation is not complete without considering the segregation patterns of minority groups. Table 3 shows the segregation among minority groups: blacks and Asians, blacks and Hispanics, and Asians and Hispanics. The format of Table 3 is the same as that of Table 2.

In general, the dichotomous H results show that blacks experience higher segregation from Asians and Hispanics than do Asians from Hispanics. However, black segregation from the other two minority groups declined between 1990 and 2000 in some selected metropolises and in the national average. Taken together with the results of the decline in segregation of

blacks and whites in Table 2, blacks were less segregated from all groups in 2000. While black segregation from Asians and Hispanics declined in the 1990s, the segregation between Asians and Hispanics increased in four selected metropolitan areas over the same decade, although not in Chicago or in the national average.

The WSR results again reveal different patterns from those indicated by the dichotomous H results. Although the dichotomous H results suggest that the segregation levels of Hispanics from Asians (Table 3) and Hispanics from whites (Table 2) are similar, the WSR results tell us that the contribution of Hispanic-white segregation is greater than the contribution of Hispanic-Asian segregation. In 2000, the contribution of Hispanic-white segregation is higher than the Hispanic-black contribution even though the dichotomous segregation levels of Hispanics from blacks and Hispanics from whites are similar (with Chicago being an exception). The increasing contribution of Hispanic-white segregation largely reflects the growing Hispanic population, which is captured in the WSR.

When we focus on the Asian group, which is small but growing fast, dichotomous segregation measures and WSRs again reveal different trends. The black-Asian dichotomous segregation declined in the national average and in three metropolitan areas (Chicago, Houston, and Los Angeles) between 1990 and 2000. The WSRs show that the contribution of black-Asian segregation to multi-group segregation increased except in San Francisco. The increase in this contribution is related to the growing Asian population in those areas, similar to the Hispanic case.

In short, combining the results from Table 2, it is clear that there has been a decline in the contribution of black segregation (from whites or from other minority groups) and a growing significance of the contribution of Asian and Hispanic segregation to multi-group segregation.

Segregation between Group and Non-Group

To further explore multi-group segregation, we studied the results of the segregation of each group from all other groups and its contribution to the overall multi-group segregation. The analysis is based on the work of Farley and Frey (1994) and others using a conventional pair-wise segregation index to understand multi-group segregation. In our analysis, we address each of the four major groups--white, black, Asian and Hispanic (see Table 4). The sum of a single group and all other groups becomes the total population, so that the two-group proportion in this set of analyses is one.

The cross-sectional comparisons of results from the dichotomous H show that blacks' segregation from the rest of the population was the highest among all groups in both 1990 and 2000 in the five metropolitan areas and in the national average, except for Los Angeles in 2000. However, the WSRs show that in comparison to the contribution of black segregation, white segregation played an equally and sometimes more important role in the overall multi-group segregation. In 1990 and 2000, the white-non-white WSR was greater than the black-non-black WSR in four of the five selected metropolitan areas and in the national average. The difference depends on whether or not the diversity and size of the groups are taken into account. In addition, the dichotomous segregation measure fails to

identify that Hispanic-non-Hispanic segregation was more important than black-non-black segregation in Los Angeles in both years and in San Francisco in 2000.

With regard to the general trend over the decade from 1990 to 2000, the dichotomous segregation indexes and the WSRs show similar patterns. However, they are different in specific situations: white-non-white in Houston, Asian-non-Asian in Chicago, and Hispanic-non-Hispanic in Chicago and New York. In addition, a consistent decline is seen in white-non-white and black-non-black WSRs, and a consistent increase is observed in Asian-non-Asian and Hispanic-non-Hispanic WSRs. The absolute magnitude of the two declines combined was about 1.5 times that of the two increases combined, explaining why the multi-group segregation declined from 1990 to 2000.

In summary, comparing the dichotomous segregation of a specific group and other groups with the WSR reveals different patterns. From the WSR results, we learn that both white-non-white and black-non-black segregation are similarly important in contributing to multi-group segregation. However, the increased contribution of Asian-non-Asian and Hispanic-non-Hispanic segregation in 2000 and the decrease of white-non-white and black-non-black segregation suggest that Asians and Hispanics played a more important role in 2000.

Conclusions

This study has developed the weighted segregation ratio (WSR) to examine the contribution of the segregation of any two groups to the overall segregation of multiple groups. Developed from multi-group segregation measures in the form of Theil's index and its additive decomposition, the WSR can quantify the percentage contribution of each group pair's segregation to the overall multi-group segregation.

For any two groups in question, the WSR is greater if the two groups' segregation, diversity, and size are higher. With these features, the WSR is different from the conventional dichotomous segregation approach, and thus yields different patterns. Because of the additive relationship of the WSR with multi-group segregation, the WSR is a useful tool to understand multi-group segregation from the point of view of two groups.

We have demonstrated the utility of the WSR for advancing research on residential segregation in multi-racial, multi-ethnic contexts. We have compared the dichotomous segregation index and the WSR for group pairs among five racial/ethnic groups in five major metropolises and in the national average in the U. S. in 1990 and 2000. We highlighted several different patterns yielded by the conventional approach in comparison to the WSR approach. First, a similar level of dichotomous segregation between two specific groups (e.g., blacks and whites) may have different percentage contributions to the overall multi-group segregation. Second, a similar level of dichotomous segregation of a group from other groups (e.g., whites and non-whites) may have different percentage contributions to the overall multi-group segregation. Third, the time trend of the dichotomous segregation of two groups may not agree with the time trend of their percentage contributions to the overall multi-group segregation.

These findings bear several implications. First, they demonstrate the limitation of using dichotomous segregation to understand multi-group segregation. Our results have shown that it is possible to misunderstand the role of groups in multi-group residential segregation when using the dichotomous segregation approach. Obvious examples are San Francisco and Los Angeles. Though dichotomous segregation measures suggest that black-white segregation has the highest level of segregation in those cities, the WSR shows that Asian-white or Hispanic-white relations contribute more to the overall multi-group segregation even though their dichotomous segregation levels are lower. These metropolises have higher proportions of Asians and Hispanics than do other cities in the study. Most metropolises in the U. S. have become more diversified as their Asian and Hispanic populations have grown. There will be increased possibility of misinterpreting the role of groups in multi-group segregation if only dichotomous segregation measures are used.

Second, our analysis identifies the rising significance of Asian and Hispanic segregation in U. S. metropolises that have higher representation of these groups. The dynamic patterns go beyond the static patterns to hint at the future development of residential segregation in multi-group American society. As studies have noted the growth of ethnic communities among Asian and Hispanic groups, more studies are needed to understand how these ethnic communities may further increase Asian and Hispanic segregation. With the ongoing large inflows of Asian and Hispanic immigrants, and higher fertility rates among Hispanics, the importance of Asian and Hispanic segregation may continue to grow in this multi-group setting.

Third, the findings demonstrate the complicated role of diversity in multi-group segregation. The findings do not show an association between multi-group diversity and multi-group segregation. However, a positive correlation between two-group diversity and the WSR is observed. The findings suggest that it is important to consider the diversity of group pairs in understanding the relationship between dichotomous segregation and multi-group segregation. Thus, the WSR provides a better understanding of inter-group relationships by taking diversity into consideration.

As recent censuses have documented the growing diversity of small cities in the U. S., the multi-racial, multi-ethnic phenomenon is no longer confined to immigrant gateway cities (Durand et al. 2005). The importance of disentangling multi-group segregation is more pressing than ever because it opens the window to understanding multi-group relations, an increasingly common urban phenomenon about which we still know very little.

Appendix

We extend the 3-group population case to the general case when the number of groups increases to M . We discuss the two types of dichotomous segregation in turn.

The first type is dichotomous segregation between two specific groups. For an M -group population, the number of all pairs of specific groups is $M(M-1)/2$, e.g., 3 pairs for a 3-group population, 6 pairs for a 4-group population, 10 pairs for a 5-group population, and 15 pairs for a 6-group population. We show that for a 3-group population and a 4-group

population, there are 3 unique ways to construct the “supergroups” so that each pair-wise relationship is included only once:

Ways to construct supergroups	3-group	4-group
1	(X,Y),Z	(X,Y),(Z,U)
2	(X,Z),Y	(X,Z),(Y,U)
3	(Z,Y),X	(X,U),(Y,Z)

For a 5-group population and a 6-group population, there are 5 such unique ways:

Ways to construct supergroups	5-group	6-group
1	(X,Y),(Z,V),U	(X,Y),(Z,U),(V,W)
2	(X,Z),(Y,U),V	(X,Z),(Y,W),(U,V)
3	(X,U),(Y,V),X	(X,U),(Y,V),(Z,W)
4	(X,V),(Z,U),Y	(X,V),(Y,Z),(U,W)
5	(Y,Z),(U,V),X	(X,W),(Y,U),(Z,V)

In each decomposition, we construct supergroups in a manner to maximize the inclusion of independent pairs of specific groups, such that the number of pairs is $M/2$ when M is an even number and $(M-1)/2$ when M is an odd number. The unique ways (J) to construct supergroups that maximize the inclusion of all pairs of groups is the total number of pairs of

groups divided by the number of pairs in each decomposition: $J = \frac{M(M-1)}{2} \div \frac{M}{2} = M-1$

for an even number M , and $J = \frac{M(M-1)}{2} \div \frac{M-1}{2} = M$ for an odd number M . If we pool all unique decompositions, each such dichotomous relationship shows up only once.

Now consider the other independent components in each decomposition. Take the first decomposition for the 5-group population as an example, where the number of independent components is the number of supergroups plus one ($3+1=4$). In addition to the two pairs of specific groups, one component is related to the multi-group segregation among two composite groups $(X+Y)$, $(Z+V)$ and a specific group U , and the other is the segregation within a single group U (which is zero). Note that these additional terms cannot be further decomposed into a dichotomous relationship between two specific groups other than X and Y or Z and V . Therefore, pooling the five decomposition results using the five unique ways of supergroup construction provides a complete set of non-redundant dichotomous

relationships among specific groups. Let $WSR_{i,j} = \left(p_{i+j} \frac{E_{i,j}}{E_{\text{total}}} \right) \left(\frac{H_{i,j}}{H_{\text{total}}} \right)$, $i \neq j$ be the WSR for specific group i and j . Let D be a collection of all terms irrelevant to the dichotomous relationships among specific groups. From Equation 6 in the text, we have a generalized additive expression of WSR measures for all non-redundant dichotomous relationships of the first type:

$$J = \sum_i^{M-1} \sum_{j=i+1}^M WSR_{i,j} + D, J = [M-1, M]. \quad (\text{A.1})$$

Then we can express the WSR as a percentage of the overall multi-group segregation using $100 \times WSR/J$, which allows us to make direct comparisons for the first type of dichotomous relationship within areas, across areas, and over time.

The second type of dichotomous relationship is that of a group and the rest of the population. There are $J = M$ unique ways to construct supergroups, since each specific group is paired once with the rest, as shown in the following tables.

Ways to construct supergroups	3-group	4-group	5-group	6-group
1	$X,(Y+Z)$	$X,(Y+Z+U)$	$X,(Y+Z+U+V)$	$X,(Y+Z+U+V+W)$
2	$Y,(X+Z)$	$Y,(X+Z+U)$	$Y,(X+Z+U+V)$	$Y,(X+Z+U+V+W)$
3	$Z,(Y+X)$	$Z,(Y+X+U)$	$Z,(Y+X+U+V)$	$Z,(Y+X+U+V+W)$
4		$U,(Y+Z+X)$	$U,(Y+Z+X+V)$	$U,(Y+Z+X+V+W)$
5			$V,(Y+Z+X+U)$	$V,(Y+Z+X+U+W)$
6				$W,(Y+Z+X+U+V)$

The “between” supergroup segregation describes the segregation of the second type of dichotomous relationship, which is obviously not obtainable from any “within” components

from the M ways of supergroup construction. Let $WSR_{i,rest} = \left(\frac{E_{i,rest}}{E_{total}} \right) \left(\frac{H_{i,rest}}{H_{total}} \right)$ be the WSR for the second type of dichotomous relationship for specific group i and the rest and D as previously defined. From Equation (6) in the text, we have a generalized additive expression of all non-redundant WSRs for the second type:

$$M = \sum_i^M WSR_{i,rest} + D. \quad (A.2)$$

. Again we can express each WSR as a percentage of the overall multi-group segregation using $100 \times WSR/M$, which allows us to make direct comparisons for the second type of dichotomous relationship within areas, across areas, and over time.

To sum up, we can compare the WSRs for the same type of dichotomous relationships, using $WSR_{i,j}$ for two specific groups and $WSR_{i,rest}$ for a specific group and the remaining groups. If we wish to compare WSRs for the two types of dichotomous relationship, these WSRs are not directly ready for this task (except for $M = 3$). Simply pooling the unique decompositions of the two types may include some dichotomous relationship more than once, because the supergroup for the rest of the population can be further decomposed into pairs of specific groups. It is essential to adjust the comparison by examining each concrete case when $M > 3$, which is beyond the scope of this paper.

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Table 1

Racial/Ethnic Group Proportions in Selected U.S. Metropolitan Areas

Metropolis	White	Black	Asian	Other	Hispanic
1990					
Chicago	0.623	0.217	0.035	0.004	0.121
Houston	0.564	0.181	0.036	0.005	0.214
Los Angeles	0.408	0.105	0.103	0.005	0.378
New York	0.479	0.232	0.061	0.007	0.221
San Francisco	0.576	0.074	0.199	0.006	0.145
US weighted mean	0.729	0.126	0.033	0.007	0.105
2000					
Chicago	0.580	0.186	0.046	0.017	0.171
Houston	0.461	0.172	0.052	0.016	0.299
Los Angeles	0.311	0.095	0.118	0.031	0.446
New York	0.396	0.227	0.090	0.036	0.251
San Francisco	0.512	0.052	0.225	0.043	0.168
US weighted mean	0.660	0.129	0.043	0.025	0.142
Change					
Chicago	-0.043	-0.031	0.011	0.013	0.050
Houston	-0.103	-0.009	0.016	0.011	0.085
Los Angeles	-0.097	-0.010	0.015	0.026	0.068
New v	-0.083	-0.005	0.029	0.029	0.030
San Francisco	-0.064	-0.022	0.026	0.037	0.023
US weighted mean	-0.069	0.003	0.010	0.019	0.038

Table 2

Specific Minority-Majority Two-group and Multi-group Segregation in Selected U.S. Metropolitan Areas

Metropolis	Black vs. White			Asian vs. White			Hispanic vs. White		
	Total E	Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H
1990									
Chicago	1.021	0.519	0.749	13.6	0.179	0.9	0.388	4.8	
Houston	1.107	0.302	0.473	11.7	0.184	1.5	0.257	7.0	
Los Angeles	1.232	0.314	0.554	7.5	0.222	3.0	0.381	10.7	
New York	1.229	0.405	0.669	12.1	0.253	1.9	0.445	7.8	
San Francisco	1.141	0.232	0.405	7.0	0.243	8.1	0.235	6.4	
US weighted mean	0.736	0.298	0.421	12.9	0.145	2.0	0.188	5.1	
2000									
Chicago	1.140	0.423	0.672	11.8	0.172	1.2	0.370	6.2	
Houston	1.242	0.281	0.469	10.0	0.232	2.2	0.305	8.9	
Los Angeles	1.306	0.291	0.506	5.9	0.261	3.5	0.401	10.8	
New York	1.386	0.364	0.670	10.9	0.268	2.5	0.450	7.7	
San Francisco	1.268	0.217	0.397	5.0	0.260	8.6	0.284	7.9	
US weighted mean	0.895	0.249	0.386	11.5	0.142	2.2	0.216	6.5	
Change									
Chicago	0.119	-0.096	-0.077	-1.7	-0.007	0.2	-0.018	1.4	
Houston	0.135	-0.021	-0.004	-1.7	0.048	0.7	0.048	1.9	
Los Angeles	0.074	-0.023	-0.048	-1.6	0.039	0.5	0.020	0.1	
New York	0.157	-0.041	0.001	-1.2	0.015	0.5	0.005	-0.1	
San Francisco	0.127	-0.015	-0.008	-2.0	0.017	0.5	0.049	1.4	
US weighted mean	0.159	-0.050	-0.035	-1.4	-0.003	0.2	0.028	1.4	

Notes: E for natural-log based diversity index, H for Theil's segregation index.

Table 3
Specific Minority-Minority Two-group and Multi-group Segregation in Selected U.S. Metropolitan Areas

Metropolis	Black vs. Asian				Black vs. Hispanic				Asian vs. Hispanic			
	Total E	Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H
1990												
Chicago	1.021	0.519	0.701	2.7	0.692	5.8	0.403	1.3				
Houston	1.107	0.302	0.378	2.2	0.375	6.1	0.295	1.8				
Los Angeles	1.232	0.314	0.507	3.8	0.354	4.6	0.260	3.4				
New York	1.229	0.405	0.612	3.7	0.335	4.2	0.320	1.9				
San Francisco	1.141	0.232	0.324	3.9	0.292	3.1	0.241	4.3				
US weighted mean	0.736	0.298	0.381	2.0	0.288	2.7	0.242	1.4				
2000												
Chicago	1.140	0.423	0.634	3.0	0.616	6.3	0.387	1.8				
Houston	1.242	0.281	0.356	2.5	0.307	5.4	0.304	2.6				
Los Angeles	1.306	0.291	0.506	3.9	0.302	4.0	0.312	4.8				
New York	1.386	0.364	0.621	4.7	0.345	4.5	0.330	2.6				
San Francisco	1.268	0.217	0.336	3.3	0.276	2.4	0.283	5.5				
US weighted mean	0.895	0.249	0.329	2.2	0.249	2.9	0.224	1.8				
Change												
Chicago	0.119	-0.096	-0.067	0.3	-0.076	0.6	-0.016	0.5				
Houston	0.135	-0.021	-0.022	0.3	-0.068	-0.7	0.009	0.7				
Los Angeles	0.074	-0.023	-0.001	0.1	-0.052	-0.7	0.052	1.4				
New York	0.157	-0.041	0.009	1.0	0.010	0.3	0.010	0.7				
San Francisco	0.127	-0.015	0.012	-0.6	-0.016	-0.7	0.042	1.3				
US weighted mean	0.159	-0.050	-0.052	0.1	-0.038	0.2	-0.018	0.4				

Notes: E for natural-log based diversity index, H for Theil's segregation index.

Table 4

Group-Non-group and Multi-group Segregation in Selected U.S. Metropolitan Areas

Metropolis	Total E	Total H	White vs. Non-white		Black vs. Non-black		Asian vs. Non-Asian		Hisp vs. Non-Hisp	
			Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H	Dichotomous H	WSR as % of Total H
1990										
Chicago	1.021	0.519	0.479	12.0	0.714	14.1	0.197	1.1	0.370	5.2
Houston	1.107	0.302	0.285	11.6	0.401	11.3	0.163	1.5	0.215	6.7
Los Angeles	1.232	0.314	0.327	11.4	0.369	6.4	0.166	2.9	0.268	9.2
New York	1.229	0.405	0.454	12.7	0.470	10.3	0.221	2.0	0.256	5.4
San Francisco	1.141	0.232	0.221	11.4	0.294	5.8	0.188	7.1	0.167	5.2
US weighted mean	0.736	0.298	0.302	14.5	0.373	12.3	0.132	1.9	0.146	4.4
2000										
Chicago	1.140	0.423	0.385	10.9	0.620	12.4	0.185	1.4	0.344	6.5
Houston	1.242	0.281	0.292	11.6	0.334	8.8	0.176	2.1	0.226	7.9
Los Angeles	1.306	0.291	0.313	10.2	0.302	5.0	0.211	4.0	0.277	10.0
New York	1.386	0.364	0.419	11.1	0.441	9.4	0.228	2.7	0.248	5.5
San Francisco	1.268	0.217	0.220	11.1	0.252	3.7	0.198	7.7	0.196	6.5
US weighted mean	0.895	0.249	0.264	13.9	0.317	10.6	0.121	2.1	0.162	5.7
Change										
Chicago	0.119	-0.096	-0.094	-1.1	-0.094	-1.7	-0.012	0.3	-0.026	1.4
Houston	0.135	-0.021	0.007	-0.1	-0.067	-2.5	0.013	0.5	0.011	1.2
Los Angeles	0.074	-0.023	-0.014	-1.2	-0.067	-1.5	0.045	1.2	0.009	0.8
New York	0.157	-0.041	-0.035	-1.5	-0.029	-0.9	0.007	0.7	-0.008	0.1
San Francisco	0.127	-0.015	-0.001	-0.3	-0.042	-2.1	0.010	0.6	0.029	1.2
US weighted mean	0.159	-0.050	-0.038	-0.6	-0.056	-1.7	-0.011	0.2	0.017	1.2

Notes: E for natural-log based diversity index, H for Theil's segregation index.

Appendix Table 1

Elements Used to Obtain Weighted Segregation Ratios

Metropolis	E_{Total}	H_{Total}	Black vs. White				Asian vs. White				Hispanic vs. White			
			p_{t+1}	$E_{i,t}$	$H_{i,t}$	$S_{i,t}$	p_{t+1}	$E_{i,t}$	$H_{i,t}$	$S_{i,t}$	p_{t+1}	$E_{i,t}$	$H_{i,t}$	$S_{i,t}$
1990														
Chicago	1.021	0.519	0.840	0.571	0.749	0.678	0.658	0.208	0.179	0.046	0.744	0.444	0.388	0.242
Houston	1.107	0.302	0.745	0.554	0.473	0.583	0.600	0.227	0.184	0.075	0.779	0.588	0.257	0.351
Los Angeles	1.232	0.314	0.514	0.508	0.554	0.374	0.511	0.502	0.222	0.148	0.786	0.692	0.381	0.537
New York	1.229	0.405	0.712	0.632	0.669	0.605	0.540	0.351	0.253	0.097	0.700	0.624	0.445	0.390
San Francisco	1.141	0.232	0.650	0.353	0.405	0.351	0.775	0.570	0.243	0.405	0.722	0.503	0.235	0.322

Note: See notations in text.