The Historical Demography of Racial Segregation *

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Abstract

Both spatial and aspatial measures of residential segregation equate spatial proximity with social distance. This assumption has been increasingly subject to critique by demographers and becomes especially problematic in historical settings. In the late 19th-century United States, standard measures suggest a counter-intuitive pattern: Southern cities, with their long history of racial inequality, had less residential segregation than urban areas considered to be more racially tolerant. Following classic accounts, we argue that traditional measures do not capture a more subtle "backyard" pattern of segregation in the South, where white families dominated front streets and blacks were relegated to alleys. We develop a sequence index that captures street-front segregation and examine its validity and reliability. Our analysis of complete household data from the 1880 Census suggests that the backyard pattern can be explained historically by the density of a city's black population, the recency of its experiences with slavery, and the occupational structure of the black labor force.

Introduction

Starting from human ecology models of urban racial patterns (Park 1926; Burgess 1926), studies of residential segregation tend to assume that individuals living geographically close to one other have a higher probability of social contact than they would with someone who lives further away. Most quantitative measures of segregation, including both aspatial (Massey and Denton 1988) and spatial (Reardon and O'Sullivan 2004; Reardon et al. 2008) indices, are based on a premise that equates proximity with potential interaction between individuals from different racial groups. This assumption has, however, been increasingly subject to critique by ethnographers and demographers, who contend that spatial distance does not adequately capture the lived experience of segregation. Urban ethnographers trace segregation through walking tours that document racial interaction in public spaces and along pedestrian paths, albeit ones that often do not follow the dictates of spatial proximity (Anderson 1992, 2011; Duneier 1994, 2013; Molotch 1972). Demographers such as Grannis (1998, 2009) have suggested likewise that modern urban populations tend to interact with those who live "down the street" from them rather than those who are closest via straight-line distance. These critiques imply that the residential patterning of racial groups may be better explained by models based on street networks and other features of neighborhoods than models based on geographic proximity or administrative boundaries among Census tracts.

The use of spatial distance as equivalent to social distance becomes especially problematic in the historical study of residential segregation in the United States. Quantitative measures of residential segregation, such as the index of dissimilarity, reveal that urban areas with a history of extreme racial inequality may have *lower* segregation scores than urban areas that are considered to be more racially tolerant. In the United States, this pattern can be traced back to the 19th century, when blacks who were engaged as slaves or servants lived in close proximity to the whites who owned or employed them (Massey and Denton 1993: Chapter 2; Lieberson 1963; Taeuber and Taeuber 1965). Between the 1960s and 1970s, a thriving demographic literature demonstrated that those Southern cities that represented the oldest urban centers of the region – and, thus, those with the deepest roots in slavery – were also the cities that historically ranked lower on standard indices of segregation (Schnore and Evenson 1966; Roof et al. 1976; Spain 1979). Following classic accounts of segregation (Johnson 1970 [1943]; Demerath and Gilmore 1954), demographers acknowledged that the ranking did not signal racial integration in these Southern cities, but might be associated with a more subtle "backyard" pattern of segregation, where white families dominated front streets and blacks were relegated to living on smaller streets and alleys. Rooted in a legacy of slavery and indicative of highly unequal status relationships between blacks and whites, the pattern of segregation along street networks was not captured by conventional measures of segregation.

Building on the early work of Agresti (1980), this paper makes use of census enumeration procedures to develop a novel sequence measure that documents street-front segregation. We suggest that the measure offers several advantages over existing measures, especially in regard to the historical study of residential segregation. First, it incorporates detailed spatial relations between housing units without recourse to household addresses or historical maps of urban centers. Second, it offers an approach that differentiates the backyard pattern from other forms of segregation, based on either straight-line spatial distance or boundaries between wards, districts, or census tracts. Finally, and most substantively, it offers quantitative evidence to address the intuition that cities with a history of racial inequality and slavery are especially susceptible to residential segregation via street networks and other neighborhood features.

Using complete household data from the 1880 Census of the United States, we investigate the empirical features of the sequence measure of segregation at two geographic levels of analysis. Our initial analysis considers the construct validity, discriminant validity, and reliability of the measure in a single city, Washington, D.C., where surviving Census district maps allow us to geocode households and draw detailed comparisons with other spatial and aspatial measures of residential segregation. As a border city between the American South and Northeast, the District of Columbia also serves as a strategic research site to investigate the pattern of residential segregation that emerged after the Civil War. We then move to a broader analysis of residential segregation in the postbellum United States, comparing the sequence measure with the index of dissimilarity in 135 cities and towns. Relative to the Northeast, our analysis suggests that the American South was indeed more susceptible to backyard segregation (or segregation via other neighborhood features) and less susceptible to the emergence of segregated African-American districts before the widespread diffusion of Jim Crow laws. This pattern can be explained by the high density of the South's black population, the recency of the region's experiences with slavery, and the occupational structure of the black labor force.

Dimensions of Historical Segregation

Past research on historical residential segregation largely uses aspatial measures, mostly based on the index of dissimilarity (e.g., Berlin 2007; Cutler et al. 1999; Kantrowitz 1979; Kusmer 1976; Lieberson 1963; Pooley 1977; Taeuber and Taeuber 1965; Trotter 1985; Tuckel et al. 2007), but also the isolation index (Cutler et al 1999; Gotham 2000; Massey and Denton 1993; Lieberson 1980) and the Gini index (Rhode and Strumpf 2003). Although aspatial indices of segregation have been repeatedly criticized on methodological grounds (see Reardon and O'Sullivan 2004), the use of spatial measures of segregation in historical research seems to have limited potential for data-driven reasons. The calculation of spatial indices of segregation requires the use of geographic data (e.g., maps of census divisions such as census enumeration districts or census blocks), which are not widely available for historical studies. Aspatial segregation measures tend to rely on relatively coarse geographic boundaries, such as city wards, when deployed in historical settings.

More importantly, neither spatial or aspatial indices capture patterns of residential segregation along streets or walking networks, where pedestrian paths are most likely to lead to face-to-face encounters between individuals from different social groups. Grannis (1998, 2009) has suggested that small residential streets are the basis of neighborly interactions in modern urban centers. Examining communities formed by tertiary street networks in Chicago, Los Angeles, and New York, he finds that they are a potent source of racial homogeneity, after controlling for spatial distance between block groups (2005).[1] Arguably, small streets and other tertiary neighborhood features are even more important to residential interaction when viewed historically, owing to the greater prevalence of foot and other non-vehicular traffic (Massey and Denton 1993). Writing in the early 1940s, Charles Johnson found a number of isolated black communities in the American South resulting from pedestrian boundaries "marked by a railroad track, stream, or other fixed barrier" (1970 [1943]: 9; see also Ananat 2011). In other urban clusters, he suggested that "the location of many Negro homes near places of employment (as domestics) [had] established a large degree of tolerance [among whites] of Negro neighbors" (ibid: 10). Even in such locales, however, other aspects of tertiary segregation and social distance tended to substitute for physical separation among blacks and whites.

[1] To be more precise, Grannis defines these tertiary residential streets as those "that have one lane on each side with no divider" (1998: 1533), and which therefore encourage pedestrian traffic rather than vehicular through traffic. Given our interest in residential segregation before the age of the automobile, we define "tertiary" streets and walks more generally as any likely pedestrian pathway in an urban center.

The classic form of tertiary segregation in the postbellum South was the backyard pattern. Johnson associated the pattern with Charleston, South Carolina in particular, where clusters of residences for black servants or tenants could often be found in the rear of the homes of affluent white families. Subsequently, social historians identified variants of the pattern in many older urban centers across the South (Demerath and Gilmore 1954; Myrdal 1944: 621; Taeuber and Taeuber 1965). In antebellum New Orleans, for instance, conditions of servitude, limited land availability, intensive monitoring of blacks, and white distrust of a cohesive black community led to widespread intermingling of slave and free black residences with white households (Spain 1979). However, the physical organization of households preserved social distance between blacks and whites. Homes of wealthy (and often slave-owning) whites faced wide boulevards on the exterior of "superblocks", while blacks lived on small interior streets and alleyways. This pattern persisted initially during the postbellum period, though the spatial segregation of blacks in New Orleans subsequently increased, precipitated by the introduction of Jim Crow and the expansion of the city's streetcar system after 1900 (Spain 1979).

In the emerging cities of the New South, black urban clusters tended to be small and scattered in the late 19th century. Cities such as Lexington, Kentucky; Durham, North Carolina; and Atlanta, Georgia did not exhibit the backyard pattern of segregation. Nevertheless, black enclaves formed in narrow zones characterized by undesirable living conditions or depressed land prices. In lieu of tertiary streets, these zones were defined by other features of local topography or land use, such as railroad tracks, cemeteries, city dumps, factories, and land with steep slopes or poor drainage (Kellogg 1977). Although white households were often not distant from black enclaves, they were more likely to be located on higher ground and away from public nuisances (ibid: 315-16).

Topography and land prices operated to sustain the social separation of blacks and whites even though the black population was fairly dispersed in many cities of the New South.

[Insert Figure 1 About Here]

These considerations point to a pattern of residential segregation that is distinct from the dimensions that have usually been assessed by aspatial and spatial measures of segregation (Figure 1). Traditional aspatial indices capture the separation of social groups across administratively or politically defined geographic boundaries. This separation – which we will term *primary* (or p-) segregation – offers only a crude assessment of the capacity of members of different groups to interact, particularly when physical segregation tends to be more local than the boundaries employed in administrative data. As an alternative, much of the recent methodological literature has pointed to spatial indices as a means to capture the separation of social groups, even if they happen to be located within the boundaries of the same administrative units. Assessment of this separation – which we will term *secondary* (or s-) segregation – offers important methodological advances, in terms of addressing the modifiable areal unit problem (MAUP) and taking full advantage of the geographic information available for recent censuses (Reardon and O'Sullivan 2004). It does not, however, address the concern that segregation may largely be a function of residential street layout or other neighborhood features that influence pedestrian paths (Grannis 2009). We will refer to this third dimension of physical separation between groups as *tertiary* (or t-) segregation. As suggested by historical examples, such as the backyard pattern and black urban clusters in the South, social groups can be separated through tertiary segregation while living in reasonably close spatial proximity or residing in the same wards or census districts.

The Sequence Index of Segregation

Drawing on Agresti (1980), we propose a Sequence Index of Segregation (SIS) that uses the ordering of households in census population listings as the basis of a measure of tertiary residential segregation. Historical population schedules consist of listings of every resident of every household visited by census enumerators, along with other information collected as part of the Census. The SIS measure rests on the assumption (examined further below) that households adjacent in the census listings were neighboring and enumerators followed typical pedestrian pathways due to census enumeration procedures. We test whether racial sequences in the population listings are serially independent – that is, we compare the observed degree of interspersal between two categories (whites and blacks in our analysis) to what would be expected under a random order. The index of segregation is computed by dividing the observed number of racially alike "runs" of households R by the expected number E(R) and subtracting this ratio from one:

$$\mathrm{SIS} = 1 - \frac{\mathrm{R}-2}{\mathrm{E(R)}-2} \qquad (1),$$

where a run is a continuous sequence of individuals of the same race in a longer sequence of individuals from two racial groups.[2] Following Agresti (1980) and Wald-Wolfowitz (1940: 151), the expected number of runs E(R) is calculated as:

$$\mathrm{E(R)} = \frac{2\mathrm{N}_1\mathrm{N}_2}{\mathrm{N}_1+\mathrm{N}_2} + 1 \qquad (2),$$

[2] For instance, a sequence of white (W) and black (B) households that is "WWW BB W BBB" would include four runs. The value of two is deducted from R and E(R), since the minimum number of runs is equal to the number of racial groups in the analysis (Agresti 1980: 393).

with N_1 and N_2 representing the number of individuals from the two racial groups that are observed in the entire sequence.

The SIS measure compares the actual amount of segregation along the path of an enumerator to that which would be observed under conditions of randomness. A value of one indicates complete segregation of the racial groups, with only two runs, while a value of zero indicates random integration. It is also possible for the SIS to be negative, when random interspersal would give rise to fewer runs than the actual sequence of residence among two racial groups, potentially as a result of conscious urban planning.

Although the sequence-based measure of segregation using the logic of runs was first proposed by Agresti over thirty years ago, it has received very limited application, primarily for data and methodological reasons. At the time, the use of historical micro-census data tended to involve tedious primary data collection. Historical demographers – including Agresti herself – had to go into the archives for particular towns and regions in order to analyze long hand-written listings of census enumerations. Now these census data are increasingly available in electronic form (e.g., via the Integrated Public Use Microdata Series). Another data limitation acknowledged by Agresti (1980: 398) was the limited time coverage for micro-census releases. Because anyone looking at the enumeration forms could see the names of respondents, the U.S. Census had not released those forms for years beyond 1880. Consequently, studies of segregation in the South had to rely on a very short time series (1870-1880s). Now the same data are available until 1940 (with identifying information) and the present (without). Finally, the methodological properties of the SIS measure were unclear: the assumption of ordered population listings was not examined empirically, the measure was not validated against alternative indices of segregation, and the measure's reliability was assumed rather than tested. To confront these methodological issues, we turn next to an analysis of the validity and reliability of the SIS measure.

Analysis of Racial Segregation in Washington, DC

To evaluate the accuracy and consistency of the SIS measure, we used 1880 Census data for Washington, D.C. The choice of the census year and city was driven both by substantive and data considerations. The 1880 Census was the last population schedule collected before the widespread diffusion of Jim Crow laws and before the Civil Rights Act of 1875 (which sought to prevent racially-biased access to public transportation and amenities) was declared unconstitutional in 1883. The Census provides an informative baseline of the levels of racial segregation that resulted in the aftermath of slavery. Washington, D.C., serves as a strategic research site for studying segregation, since it had been a "border" city during the antebellum era, with a relatively large free black population and a mixture of prototypical Northern and Southern patterns of racial residence.[3] Data considerations also point to the utility of studying the pattern of residential segregation in Washington at the time. Among all nineteenth-century censuses, the 1880 Census is the only one for which data for the entire population (i.e., 100% enumeration) is currently available via IPUMS (Ruggles et al. 2010). Washington is one of the few cities from the postbellum period with surviving enumeration districts maps, which are required for spatial analysis.

[3] During the Civil War, Lincoln issued his first emancipation act for Washington, D.C. (in April of 1862). This early instance of black freedom does not seem to have desegregrated the city relative to Southern urban centers. Indeed, observing the effect of Jim Crow laws in the early 20th century, Charles Johnson (1943: 7) wrote that, in Washington, "there is more rigid segregation and rejection of Negro patronage in the large department stores". For cities in the border area, Johnston continued, "it is frequently necessary to be more explicit regarding segregative intent than in the South" (ibid).

In 1880, the population of Washington, D.C. included 149,057 inhabitants. We excluded the institutionalized population from analysis, which represented 6 percent of the total. We also excluded non-whites and non-blacks, which only subsumed 14 cases among the non-institutionalized population. Finally, we dropped 128 cases that fell in the category of "partner, friend, or visitor" (based on their relationship to the household head). The resulting sample size was 143,251 (68% white), and consisted of 29,145 households. If non-relatives (particularly, servants) are identified as part of households, then 11 percent of the households in Washington were mixed race at the time. If non-relatives are not taken into account, then only 76 households were mixed-race (less than 1 percent). Since mixed-race households (apart from servants) were quite rare in 1880, we limit our analysis to the race of household heads, treating households themselves as racially homogeneous. Our final sample includes white (67%) and black (33%) household heads with a total of 29,145 cases.

From 1880 until 1930, records in the census were arranged by enumeration districts (analogous to modern census blocks). In the 1880 Census, the city of Washington, D.C. was divided into 82 enumeration districts, numbered from 9 to 90 (the first eight districts were in the suburbs). Only residents living within the city limits were included in our analysis. Because enumeration districts are the smallest discrete geographic unit in the 1880 Census, we used these districts for purposes of aspatial analysis and detailed comparisons across segregation measures. The number of households per district ranges between 108 and 710, with a mean of 421 and standard deviation of 149.

For the spatial analyses, we utilized several maps. We examined the 1880 Census enumeration district map (National Archives and Records Administration 2003) and supplemented it with a landownership map that dates back to 1861 (McClelland, Blanchard and Mohun 1861), reflecting building sites and patterns of land use immediately before the end of slavery in the District of Columbia. Because both maps were image-based, we then georeferenced them in ArcGIS 9.3 (Environmental Systems Research Institute 2008) using the modern map of Washington streets (District Department of Transportation 2012) as a control layer. The contemporary map was informative because the city's street layout has changed very little since the 1880s. For the enumeration district map, we drew the boundaries of enumeration districts on a new GIS shape file. We also used the 1888 Sanborn map for Washington (Sanborn Map Company 2001) to locate streets that had been renamed since the late 19th century or do not exist anymore.

Construct Validity of SIS

The basis for the sequence-based index of segregation rests on the assumption that most households listed consecutively in the census population listings were also neighbors in real life (Agresti 1980). Starting with the 1850 Census, the instructions to enumerators explicitly required them to number households "in the order of visitation" and maintain records in the same order (U.S. Census Bureau 2002: 19; Wright and Hunt 1900). Furthermore, since enumerators had to visit every household, we can assume that census takers moved in a systematic sequence between neighboring households along well-established pedestrian routes. Historical evidence on census procedures suggests that enumerators indeed "went from cabin to cabin" (Magnuson and King 1995) or house-to-house down the same street, across the street from one another, or around the corner. By the turn-of-the-century, instructions to enumerators specified methods for canvassing each district. Urban districts with street blocks were to be canvassed "by blocks or squares" with enumerators beginning at one corner and following a pedestrian route "entirely around [the block] and [then] through it" (U.S.

Census 1900: 17), thus covering neighboring households on front streets, followed by interior alleys, passageways, and other tertiary streets, before moving on to another block.

To examine whether the assumption of sequential street-front enumeration is valid, we geocoded the 1880 Census data for Washington, D.C. Specifically, we mapped locations of individuals in the Census to our GIS data. Two data limitations complicated our spatial analyses. First, street address data is available only for those households that were included in the IPUMS 10% sample. For Washington, street address information is available for 7,987 household heads, or 27.4 percent of our entire sample. In addition, we could not locate 348 cases (or 4.4 percent) because the street data were unclear, so our spatial analysis of construct validity is limited to 7,639 cases. Second, street address data available through IPUMS does not include house number information. Therefore, we overlaid the city map with the Census enumeration district map to ensure that people who lived on the streets that belonged to two or more districts are mapped to the correct district. We also used the landownership map as a guide to where buildings were more scattered or closer to one another. As a next step, we inferred the local enumerator's visitation route.

Here, we illustrate our analysis on the 10th enumeration district in Washington, D.C. (see Figure 2).[4] Located in the middle of the historical part of Georgetown, district 10 has the shape of a right-angled triangle, with Market [now 33rd] and Prospect Streets as legs and High Street [now Wisconsin Avenue] as a hypotenuse. Among the households for which address data are available, we observe continuous street sequences in the Census listings (see Table 1). For the 10th enumeration district, 26 observations with serial numbers 884470-884493 (e.g. 884470, 884471, 884472 ... 884493) and 884525-884526 were located on High Street [now Wisconsin Avenue], 5

[4] The spatial analysis for the entire city is available in supplemental documentation.

observations with serial numbers 884527-884531 were located on Market Street [now 33rd Street]; 12 observations with serial numbers 884576-884587 were located on Prospect Street; 8 observations with serial numbers 884620-884627 were located on 1st Street [now N Street]; and 21 observations with serial numbers 884664-884684 were located on 2nd Street [now O Street].

[Insert Figure 2 and Table 1 About Here]

Because the serial number represents the order in which households were enumerated, it seems reasonable to assume that the enumerator started moving at the intersection of Prospect and High, went up High, then down Market, and then walked down Prospect until the starting point (thus completing the boundaries of the triangle). (S)he then visited households on the interior of the city block – including 1st and 2nd Streets -- but we do not know the exact enumeration route. (S)he may have started from the east part of 1st Street, moved along this street to the west and then started from the west part of 2nd Street, or she may have started from the west part of 1st Street, moved along this street to the east, and then started from the east part of 2nd Street. In either case, the pattern of visitation is consistent with our conceptualization of *t-segregation*, which considers the adjacency of households on front streets of city blocks separately from their adjacency to households on streets and alleys within a block.

Based on our spatial analysis of this and other enumeration districts, we see that in the vast majority of cases the Census enumerators moved between adjacent households facing the same street. To quantify this further, we noted that address information was available for 585 street segments in Washington, D.C. For 32 of these segments, street data was available for only one household, making them less informative for the purpose of assessing construct validity. Among the remaining

553 street segments, 390 segments display unbroken enumeration sequences (as do all streets in district 10 except for High Street). Another 163 street segments have enumeration sequences that are only broken by sampling gaps, similar to those observed for High Street. The remaining 59 street segments exhibit sequences interrupted by other street segments. Presumably, in those cases, the enumerator came back to visit houses where residents were absent the first time (s)he visited the street, or (s)he moved along blocks rather than entire streets. Thus, it is reasonable to assume that households adjacent in the census listings were generally also neighbors and that the sequence of enumeration would help identify areas with small homogenous urban clusters or the backyard pattern of segregation.

Discriminant Validity of SIS

We next computed the sequence index of segregation for all of Washington, D.C. and compared it with other popular measures of segregation. On the city-wide level, the SIS is equal to .68, meaning that 68 percent more of adjacent household pairs were of the same race than would be expected under conditions of random integration. Because the SIS assesses segregation at a very small scale, its values are consistently higher than those of other commonly used measures of segregation, both spatial and aspatial (see Table 2).[5] At the level of enumeration districts, the values of SIS vary between -.05 and .81, with a mean of .58 and standard deviation of .16. It is worth noting that the weighted mean (by enumeration district size) is approximately .62 and is quite close to the SIS value computed at the city-wide level (e.g., as one long run). While the parallel aspatial and spatial

[5] We computed the spatial indices of segregation using the macro called SpatialSeg written in Visual Basic Basic for Applications and run within ArcGIS 9.3 (Environmental Systems Research Institute 2008). This macro was developed by Sean Reardon and colleagues (see, for example, Reardon et al. 2008) and is available at http://www.pop.psu.edu/services/GIA/research-projects/mss/mss-about. We computed the spatial indices using cell size of 10m, radius of 10m, and pycnophylactic smoothing. Because the SIS captures segregation at a granular scale, we used the smallest values of cell size and radius that gave stable estimates.

measures (e.g., the aspatial and spatial dissimilarity index) have almost identical values, the higher value of the SIS suggests that it may be tapping into a different dimension of residential segregation.

[Insert Tables 2 and 3 About Here]

To examine the discriminant validity of the SIS at a more fine-grained level, we contrasted the SIS values with the spatial information theory index ($\widetilde{H}$ at 10m/10m) at the level of enumeration district pairs. Our preference for the spatial information index is based on a recent evaluation of segregation measures that find it to be more conceptually and mathematically satisfactory than other commonly used segregation indices, both spatial and aspatial (Reardon and O'Sullivan 2004). We conducted the analysis for pairs of adjoining enumeration districts in order to assure that the sample of households in each geographic unit was sufficiently large to reliably calculate the $\widetilde{H}$ index.[6] To pair the districts, we took odd-even pairings of the contiguous districts in sequence (for example, we paired the districts 9 and 10, then 11 and 12 and so on). In a few instances, we paired the districts that were out of numerical sequence in order to preserve geographic adjacency. We analyzed 41 pairs in total (Table 3). Across the district pairs, the pairwise correlation between the two measures of segregation is equal to 0.13 and is not statistically significant (critical value of 0.3, assuming a random sample of district pairs, a two-tailed test, and alpha equal to 0.05).

While the SIS and the spatial IT index may be tapping into conceptions of spatial segregation that are broadly similar, the modest correlation suggests that they have notable distinctions. The SIS measures segregation between neighboring houses located on the same street (or around the same

[6] Analyzing all of the enumeration districts separately produced negative values for the spatial information theory index in some instances.

corner), since the enumerator moves from house to house based on addresses that are located next to one another on a street. The spatial information theory index, on the other hand, measures segregation on the basis of continuous distances, and as such is sensitive to the collocation of black and white households, even if those households are only adjacent in the back (and, perhaps, separated by a fence or other physical barriers). In other words, the SIS captures street-front segregation, while the spatial information theory index also takes into account neighboring households from parallel and perpendicular streets.

[Insert Figures 3 and 4 About Here]

To illustrate this further, we performed a visual side-by-side comparison of the district pair (51+52) that has the lowest rank-order difference between these segregation measures (Figure 3) and the district pair (19+20) that has one of the highest rank-order differences (Figure 4). In the pair 51+52, one observes fairly high levels of racial interspersal on nearly all of the streets (i.e., mixed racial composition of streets), suggesting low levels of both street-front and spatial segregation. In the pair 19+20, most of the streets and alleys demonstrate lower racial interspersal, with some of them being entirely monoracial. However, neighboring streets and alleys in this district-pair often have residents of different races. This is especially visible when one takes alleys (e.g., narrow lanes that run inside blocks) into account. For example, all of the alley residents inside the bottom left block of enumeration district 19 (left-hand side district on Figure 3) are black, while three of the four front streets of this block are entirely white. It seems reasonable to expect low levels of social contact and interaction between residents of alleys and front streets in this block. The SIS captures this pattern of tertiary segregation, assigning one of the largest values in the city to this district-pair, whereas the spatial index of segregation indicates low levels of secondary segregation.

Reliability of SIS

Since the SIS is based on the order of enumeration, one concern that may arise is how sensitive it is to random "breaks" in the sequence, e.g. when households adjacent in the census listings are not neighbors. Our analysis for Washington, D.C. suggests that census enumerators generally moved between neighboring households within districts. However, aggregation may introduce noise into the measure, similar to the modifiable areal unit problem (MAUP) for aspatial indices. When the SIS is computed at the city-wide level, the sequence is sorted by enumeration district number and then serial number (within enumeration districts). The implicit assumption is that the last person enumerated in district *n* is neighboring with the person listed first in district *n+1*, which need not be the case. First, the finishing location of district *n*'s enumeration is not necessarily the same as the starting location of district (*n*+1)'s enumeration, particularly when those schedules were prepared on different days. Second, different districts were often canvassed by different enumerators (Magnuson and King 1995). Finally, many spatially adjacent districts do not have consecutive numbers. For example, district 24 not only shares boundaries with district 25, but also with 18, 19, 20, and 26.

[Insert Figure 5 About Here]

Focusing on Washington, D.C., we performed two sets of analyses to assess how sensitive the SIS is to breaks in the sequence introduced by aggregation from the district level to the city level. First, we computed SIS values for n=1,000 sequences of randomly ordered enumeration districts. Figure 5a shows that the resulting distribution of SIS is roughly normal and very narrow, with a mean of .6809 and standard deviation equal to .0002. Second, we ordered enumeration districts based on a spatial contiguity rule, moving from one enumeration district to a randomly selected adjacent non-enumerated district.[7] The resulting distribution of SIS is also very narrow, with a slightly higher mean of .6818 and the same standard deviation equal to .0002, as well as a roughly normal distribution (see Figure 5b). Two findings stand out here. First, in both cases, the mean value of SIS is very close to the one obtained when enumeration district are ordered based on their census number (.6819). Second, the mean value of SIS when enumeration districts are ordered based on a spatial contiguity rule is closer to the one obtained when districts are sorted based on their census numbers. This seems to be the case because spatially adjacent enumeration districts are often numbered consecutively. In either case, there is little reason to suspect that variations in district order across cities will have any substantive impact on the calculation of the sequence index of segregation.

Analysis of Racial Segregation across U.S. Cities in 1880

When applied to urban centers in the 19th and early 20th century, standard quantitative measures of residential segregation reveal a paradoxical pattern: Southern cities, with their long history of extreme racial inequality and slavery, exhibited lower levels of segregation between blacks and whites than urban areas in other regions of the country. Our exploratory analysis of the discriminant validity of the SIS measure suggests that it captures a different type of racial segregation than other quantitative measures, both spatial and aspatial. To examine the prevalence of tertiary segregation

[7] In instances where all of the adjacent enumeration districts had already been enumerated (i.e., included in the sequence), the algorithm moved to a randomly selected (already enumerated) adjacent district and then randomly selected one of its adjacent districts. The algorithm continued if this randomly selected "adjacent to an adjacent" district had not been yet enumerated, or repeated the cycle until it selected a district that had not been enumerated yet.

on a broader scale, we next tested regional variation in the SIS and compared it with the dissimilarity index for American cities in the postbellum era.

As in our previous analyses, we used the 1880 Census data for the entire population, but now employed cities as our units of analysis. We restricted the sample to incorporated cities with at least 5,000 residents and at least 50 black households. We imposed the minimum threshold for the black population since segregation indices cannot be reliably calculated for cities with small minority populations (Iceland et al. 2002). All cities in our sample have at least two enumeration districts (cities with a single district would not have a meaningful index of dissimilarity). The final sample of cities that meet these criteria is N=135. We also tried alternative criteria for the city sample and findings were substantively similar.

Our dependent variables are the SIS and the aspatial dissimilarity index. The aspatial dissimilarity index was chosen as a basis of comparison for two reasons. First, the use of "gold standard" spatial indices was impossible due to the limited availability of spatial data for 19th century American cities. Second, among the aspatial indices, the dissimilarity index has received the widest attention in previous historic research of residential segregation. To compute the city-level SIS and D, we excluded the institutionalized population and non-whites and non-blacks from the analysis. Following our preliminary examination of segregation patterns in Washington, DC, the analysis is again based on the race of household heads.

Our primary independent variable of interest is region. The modern Census definition splits the contiguous United States into four regions: Northeast (CT, ME, MA, NH, NJ, NY, PA, RI, VT), Midwest (IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI), South (AL, AR, DE, DC, FL, GA,

KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV), and West (AZ, CA, CO, ID, MT, NV, NM, OR, UT, WA, WY). However, the U.S. West was very sparsely populated in 1880, with much of that part of the country in the form of territories rather than states. The handful of cities in the West were concentrated in California, along with Portland, OR and Salt Lake City, UT. To ensure a sufficiently large regional sample of cities, we combined the West and Midwest into one category, referred to as the "Far and Midwest" in the analyses below. We also placed the so-called "Border States" -- which allowed slaveholding until the end of the Civil War but did not secede from the Union -- in the Southern region. This category includes Missouri, Kentucky, Maryland, Delaware, and the District of Columbia. A final special case was West Virginia, which separated from Virginia in the middle of the Civil War to become a Union state. We also treated it as part of the South. Thus, our regional division involves only two modifications from the standard Census Bureau definition of region: (1) combining the West and Midwest in one category; and (2) moving Missouri to the South. We employ the Northeast as the reference category.

We added other city-level variables to our models to see whether they could explain the association between region and type of residential segregation. These variables include city size, the proportion of the population that is black, the time lag since the abolition of slavery, and the occupational composition of the black labor force.[8] The inclusion of these variables is guided by previous literature that has linked city size and the prevalence of the black population with black-white residential segregation historically (Marshall and Jiobu 1975; Logan et al. 2004; Iceland et al. 2013). We also test the hypothesis that the decay of institutionalized status differences between blacks and whites following the end of slavery increases the tendency toward residential segregation (Wilson 2012). While popular perception has often associated the institution of slavery uniquely with the

[8] The time lag since emancipation is a state-level variable (all others are city-level).

South, many other regions of the United States only gradually eliminated black bondage between the late-18th and mid-19th century (Ruef 2014: Chapter 8). New York City, for instance, was heavily dependent on slaves in domestic service and industry until it completed gradual emancipation, inducing high levels of residential proximity among blacks and whites in the early 19th century (White 1991). Our analysis takes advantage of the considerable state-level variation in the year of abolition of slavery in the Northeastern and Western states, ranging from 1783 in Massachusetts to 1861 in Kansas.

Historical accounts of the backyard pattern of segregation also suggest the importance of the occupational structure of black population, with a special attention to service workers. We grouped the occupations available in the Census data into five broad categories: (1) service workers (including domestic servants);[9] (2) professional and white-collar occupations; (3) manufacturing; (4) retail and wholesale; and (5) other laborers. Our results are robust to alternative categorizations of the occupational data. We entered the proportions of black workers in each occupational category as predictors in our models, with the proportion in professional and white-collar occupations as the reference category. The choice of the omitted category was driven by the intuition that cities with a larger black middle class would have more residential integration. Accordingly, we considered how the redistribution of the black labor force to other occupational categories affected residential segregation.[10]

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[9] In the interest of parsimony, we combined domestic servants with other service workers (e.g., launderers / laundresses). There are substantive reasons to believe that spatial segregation was low for this larger group, as well as for domestic servants in particular. For instance, 19th century cities had numerous "residential" hotels with white tenants, which would draw upon black workers who lived nearby (low primary and secondary segregation) but out-of-sight (high tertiary segregation).

[10] Aside from black labor force composition, previous research suggests that white-black status differences may affect residential segregation (Iceland and Wilkes 2006). We ran additional models with the mean occupational status difference between whites and blacks for each city as a predictor. These coefficient

In the multivariate analyses, we present two sets of ordinary least squares (OLS) regression models that predict tertiary segregation (SIS) and primary segregation (D) with regional dummies and city-level variables.[11] Other research on city-level variation in segregation has sought to capture so-called "net micro-segregation", isolating patterns of segregation at a smaller scale that are free of segregation at a larger scale (Lee et al 2008; Reardon et al 2009). As applied here, this suggests testing the effects of our theoretically-derived predictors on one dimension of segregation, while controlling for the other dimension, in order to capture the net segregation effect.[12] We tested these alternative model specifications as well and the analyses led to substantively similar results when SIS and D were included as independent variables.

Descriptive Results

We begin with descriptive statistics that show regional variation in the sequence index of segregation and the dissimilarity index. Table 4 summarizes the mean values of variables used in the analysis. Given that it measures residential segregation at a more granular level of spatial analysis, the SIS is larger on average than the D (.454 compared to .386) when the sample of 19th century cities is considered as a whole. However, these means disguise considerable regional variation. We find that the dissimilarity index is lowest in urban areas within the late 19th century South and highest in the

estimates for occupational differences were not statistically significant and did not alter the effects of other variables.

[11] Technically, it is not entirely appropriate to use OLS regression in this case because the dependent variables in our regression models are truncated (i.e. values of the SIS and D range between 0 and 1). However, the use of regression models for truncated dependent variable leads to substantively similar results. Histograms as well as skewness and kurtosis statistics suggest that both SIS and D approximate normal distributions. Also, an inspection of raw, standardized, and studentized (jack-knifed) residual plots does not reveal any discernible trend or pattern, suggesting no considerable violations of OLS regression assumptions due to truncated dependent variables.

[12] Specifically, this calls for the inclusion of D as an independent variable in the models predicting SIS to explain patterns of tertiary or micro-segregation (captured by the SIS) that are free of primary or macro-segregation (captured by the D), and vice versa.

North. The sequence index of segregation, on the other hand, suggests the opposite pattern: when tertiary segregation is taken into account, including the backyard pattern and the existence of small homogenous urban clusters, residential segregation was actually *higher* in the South than in the Northeast.

[Insert Table 4 About Here]

The table reveals considerable regional variation in some independent measures and uniformity in others. The cities of the late 19th century South tended to be smaller than those in the Northeast (Doyle 1990) and featured a much larger black population than those of any other region of the country. Service occupations represented the most common jobs for urban blacks in 1880 and the proportion of the black labor force in these occupations did not exhibit much regional variation. Multivariate analysis is required to identify whether potential effects from these characteristics can be traced to the relative prevalence of the two forms of segregation, or whether more subtle regional differences are at play.

Multivariate Results

As a final stage of our analysis, we estimated OLS regression models to examine the association between city characteristics and the magnitude of primary and tertiary segregation. The baseline model is limited to the regional dummy variables shown in Table 4. We then present nested models, where we add all of the city-level variables of theoretical interest and then add the two model specifications with black labor force composition.

[Insert Table 5 About Here]

Tables 5 displays the results of OLS regressions in which the dissimilarity index and the sequence index of segregation are the dependent variables. Consistent with the descriptive findings described earlier, the regression results show significant regional differences in the type and level of residential segregation (Models 1 and 5). On average, segregation scores in the South are .05 points higher than in the Northeast based on the SIS, but .23 points lower based on the D index. While previous scholars attributed lower scores of the D in the South to higher levels of integration, our analyses point to two qualitatively different types of segregation that emerged in the Northeast and South. During the postbellum era, the Northeast had higher levels of primary segregation, as evidenced by the separation of blacks and whites across administrative Census boundaries. In contrast, the South had higher levels of street-front or tertiary segregation. And the West did not show much evidence of either. In northern cities, blacks were clustered in different areas of the city (e.g., districts) from whites, whereas in southern cities blacks were relegated to living on different streets than whites (within the same districts). These results suggest that residential segregation in the South took place at a smaller spatial scale than in the Northeast (Reardon et al 2008). Our results also echo the qualitative intuition of mid-twentieth century studies on segregation about the backyard pattern that have been missed by the modern quantitative literature on segregation.

Some of the regional differences in the type and level of residential segregation between the Northeast and South appear to be explained by city size, density of the black population, "institutional decay" since the abolition of slavery, and occupational composition of the black population. While the expanding size of cities is consistently linked to increases in both forms of black-white segregation, the density of the black population has very distinct effects on primary and tertiary segregation. In the late 19th century, the estimates suggest that increases in a city's black population decreased the propensity among African-Americans to form an ethnic enclave in a separate district and, at the same time, increased the tendency for them to experience street-front segregation. The addition of this variable alone accounts for much of the difference in tertiary segregation between the South and Northeast.

Our results also point to an institutional explanation for differences in the index of dissimilarity. Even after controlling for city size and the density of the black population, Northern cities display significantly greater levels of primary segregation than those in the South (model not shown). Once we introduce a variable for the time lag since the end of slavery, this regional difference becomes statistically insignificant (Model 6). The finding suggests that the physical segregation of blacks and whites in the Northeast may have emerged over time as a substitute for the status inequality between black slaves and free whites during the early American Republic (White 1991).

Finally, our results lend quantitative support to the role of occupational structure in producing the backyard pattern in residential segregation. Our analyses show that cities with a higher proportion of black workers employed in service occupations, including domestic servants, displayed greater levels of tertiary residential segregation (Model 3). Similar patterns are observed for the proportions of black workers in manufacturing and in retail or wholesale trade (Model 4). However, none of the coefficients on the occupational variables are significant in explaining primary segregation (Models 7 and 8).

While black urban density and the time since abolition seem to account for much of the difference in segregation patterns between the South and Northeast, the models do not explain the regional differences between the West and other parts of the country. Across all of the models, cities in the

Far and Midwest consistently display lower levels of both tertiary and primary segregation, even once the city-level variables are included.

Conclusion

In this paper, we offer both methodological and substantive contributions to the literature on residential segregation. By making use of census enumeration procedures, we develop a novel sequence measure of segregation. Our analyses of the proposed index's empirical features suggest improvements on commonly used measures, both spatial and aspatial. While standard segregation indices explicitly treat spatial proximity as equivalent to social distance, the sequence index of segregation captures street-front segregation. When applied to historical Census data on the United States, standard measures assign lower racial segregation scores to Southern cities (particularly those with a long legacy of slavery) than urban areas that may be considered to be more racially tolerant. In contrast, the SIS lends support to the "backyard" pattern as a distinctive form of residential segregation that emerged in the South, largely as a result of the high density of the black population and the heavy dependence of Southern white households on black domestic service.

The sequence measure parallels recent efforts to incorporate more nuanced conceptions of space into the analysis of urban segregation (e.g., Grannis 2009). It does so by reducing the separation of populations in two or three dimensions to a single dimension that tracks typical walking paths through urban areas. Defined in this way, the measure is particularly useful for historical contexts where vehicular traffic is absent or negligible, and census or other assessors rely on house-to-house enumeration, rather than mail-in surveys, phone interviews, or other means of collecting demographic data. As employed here, the sequence measure remains a property of districts, wards, census tracts, neighborhoods, or other geographic divisions of cities. Extension to the micro-level may be desirable when researchers seek to trace the effect of segregation on individuals and households. We suggest that sequences of neighbors may be informative in this respect as well, particularly if those sequences are analyzed with distance-decay or similar functions that have become widely used in the analysis of spatial segregation (Reardon et al. 2008). Additionally, the SIS can be extended to other, potentially multi-group, attributes of interest, such as ethnicity, religious affiliation, or socioeconomic status.

Further research is needed to understand the scope conditions under which sequence-based segregation is likely to impact outcomes and perceptions among urban residents. While well-suited to historical research, the SIS measure only captures a relatively narrow set of conditions undergirding the contact hypothesis (Allport 1954) and thus only partially addresses the possibility of improved interracial relations as a result of reduced segregation. An important conceptual limitation of the measure is its emphasis on segregation in urban public spaces. Racial-ethnic categories may be a potent source of social segregation in public, but this need not extend to interactions in private settings (Britton 2008).

The results reported here are based on the 1880 U.S. Census, the only census year for which complete household data for the United States are readily available through the IPUMS project. However, increasingly more microdata based on complete census schedules, both in the U.S. and internationally, are being distributed through initiatives like the North Atlantic Population Project (NAPP) (Ruggles 2012). Similarities in enumeration methods among historical Census data allow the use of SIS measures for historical examinations of segregation across time and space. For instance, the preliminary complete count data for the 1850 U.S. Census is now available via the

NAPP. The 1850 Census was the first Census when enumerators were explicitly instructed to number households in the order of visitation and keep completed schedules in the same order. Future comparative historical research could make use, for example, of the complete 1881 Census of Canada and the complete 1881 Census of England and Wales, also available through the NAPP. In Canada, enumerators were instructed to visit households "from house to house" (Department of Agriculture 1881) and in England and Wales the instructions to census enumerators advised them to keep completed census schedules "arranged as they are collected" (Census of England and Wales 1881).

Methodologically, additional analysis is required to explore the properties of the SIS measure under sampling. It is likely that the SIS proves reliable when applied to smaller samples, under the condition that entire pages from the manuscript censuses are sampled rather than individual households (the former sampling method is used by IPUMS). If the SIS is generally subject to limited sampling error, then it can be applied to other Census schedules without complete count data in the U.S. and abroad. For example, the SIS could be used to study the evolution of racial segregation as the Jim Crow system progressed from the 1880s onward.

The sequence index of segregation equips researchers with a method for further historical scholarship on trends in racial segregation. In the United States, a substantial limitation of previous research on historical racial segregation is its exclusive reliance on aspatial indices, which fail to capture the diverse forms of segregation that emerged with Jim Crow in postbellum America. Understanding the causes and patterns of the historical evolution of racial residential segregation may inform our analysis of its current forms. Future research should address this gap by documenting the SIS in different historical contexts, on its own or in combination with other measures of racial segregation.

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Table 1. Ordered Sequences of Serial Numbers for Enumeration District 10 and Inferred Route

Order of visitation	Street	N	Sequence of serial numbers	Direction of visitation
1	High Street [now Wisconsin Avenue]	26	884470-884493 and 884525-884526	From South to North
2	Market Street [now 33rd Street]	5	884527-884531	From North to South
3	Prospect Street	12	884576-884587	From West to East
4	1st Street [now N Street]	8	884620-884627	East -- West
5	2nd Street [now O Street]	21	884664-884684	West -- East

Table 2. City-Level Indices of Segregation between Blacks and Whites, Washington, D.C., 1880

Segregation index	Value
Sequence Index of Segregation (SIS)	0.681
(Aspatial) Dissimilarity Index (D)	0.335
(Aspatial) Information Theory Index (H)	0.117
(Aspatial) Exposure Index (X)	0.281
Spatial Dissimilarity Index 10m/10m ($\widetilde{D}$)	0.337
Spatial Information Theory Index 10m/10m ($\widetilde{H}$)	0.122
Spatial Exposure Index 10m/10m ($\tilde{P}^*$)	0.280

Source: Authors' calculations using the 1880 Census data.

Table 3. Comparison of SIS with H for Paired Enumeration Districts in Washington, D.C. (1880)

Pair of Enumeration Districts	SIS	H	Rank SIS	Rank H	Rank Difference
22+23	0.594	0.012	26	26	0
51+52	0.542	0.007	32	32	0
29+30	0.757	0.200	2	1	1
17+18	0.711	0.043	11	12	1
85+88	0.662	0.021	18	17	1
53+54	0.564	0.011	29	28	1
83+84	0.719	0.123	7	5	2
35+36	0.619	0.019	22	20	2
72+73	0.684	0.021	15	18	3
59+60	0.659	0.033	19	15	4
55+56	0.547	0.002	31	35	4
67+68	0.502	0.010	35	30	5
77+78	0.790	0.115	1	7	6
41+42	0.716	0.153	9	2	7
37+38	0.527	0.000	33	40	7
57+58	0.724	0.035	6	14	8
45+46	0.294	0.005	41	33	8
15+16	0.669	0.013	16	25	9
81+82	0.628	0.059	20	11	9
11+12	0.559	0.015	30	21	9
86+87	0.691	0.136	14	4	10
39+40	0.668	0.012	17	27	10
49+50	0.718	0.019	8	19	11
13+14	0.577	0.032	27	16	11
9+10	0.521	0.014	34	23	11
43+44	0.491	0.013	36	24	12
63+64	0.601	0.000	24	38	14
79+80	0.628	0.001	21	36	15
74+75	0.601	0.000	23	39	16
33+34	0.598	0.093	25	8	17
24+25	0.750	0.015	3	22	19
21+28	0.706	0.008	12	31	19
69+76	0.566	0.115	28	6	22
65+66	0.738	0.010	4	29	25
26+27	0.713	0.001	10	37	27
47+48	0.475	0.060	37	10	27
89+90	0.350	0.038	40	13	27
70+71	0.702	0.000	13	41	28
19+20	0.730	0.004	5	34	29
31+32	0.392	0.093	39	9	30
61+62	0.452	0.153	38	3	35

Table 4. Means and Standard Deviations for Variables Used in Regressions, by Region and Entire Sample

	Northeast		South		Far and Midwest		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sequence Index of Segregation (SIS)	.484	.114	.534	.098	.358	.132	.454	.137
Aspatial Dissimilarity Index (D)	.487	.139	.253	.113	.382	.158	.386	.167
City-Level Variables								
City Population (in tens of thousands)	9.886	21.363	5.227	8.173	4.959	8.589	6.894	14.800
Proportion Black	.027	.019	.335	.174	.055	.069	.121	.165
Years Since Emancipation	54.333	23.229	15.162	.687	76.148	26.177	51.192	31.896
Occupational Structure of Black Labor Force								
Proportion in Professional / White-Collar Occupations	.096	.058	.054	.016	.133	.059	.097	.059
Proportion in Service Occupations	.773	.080	.797	.074	.735	.082	.766	.083
Proportion in Manufacturing	.093	.046	.113	.054	.101	.040	.101	.047
Proportion in Retail / Wholesale	.016	.011	.009	.003	.013	.010	.013	.010
Proportion in Other Labor	.021	.026	.024	.026	.015	.014	.020	.023
Number of Cities	51		37		47		135	

Note: All cities with at least 5,000 residents and at least 50 black households are included in the calculations.

Source: 1880 Census.

Table 5. Coefficients from OLS Regression Models of Racial Residential Segregation in U.S. Cities, 1880

	Sequence Index of Segregation (SIS)				Aspatial Dissimilarity Index (D)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Region								
Northeast (omitted)								
South	.050*	.023	-.000	.005	-.233***	-.081	-.060	-.071
Far and Midwest	-.125***	-.135***	-.127***	-.099***	-.104***	-.109*	-.112***	-.118***
City-Level Variables								
Population		.002***	.002***	.002***		.004***	.004***	.004***
% Black		.229*	.312**	.187		-.240*	-.315**	-.257*
Years Since Emancipation		.001	.001**	.001*		.001**	.001*	.001*
Occupational Structure of Black Labor Force								
Proportion in Professional / White-Collar Occupations (omitted)								
Proportion in Service Occupations			.507***	.999***			-.223	-.290
Proportion in Manufacturing				.956**				-.121
Proportion in Retail / Wholesale				2.253*				.385
Proportion in Other Labor				.534				-.710
Intercept	.484***	.407***	-.006	-.499**	.487***	.370***	.555***	.629**
Adjusted R^2	.272	.375	.451	.519	.300	.503	.515	.513

* *p*<.05; ** *p*<.01; ****p*<.001 (two-tailed tests)

N=135 cities

Figure 1. Dimensions of Residential Segregation

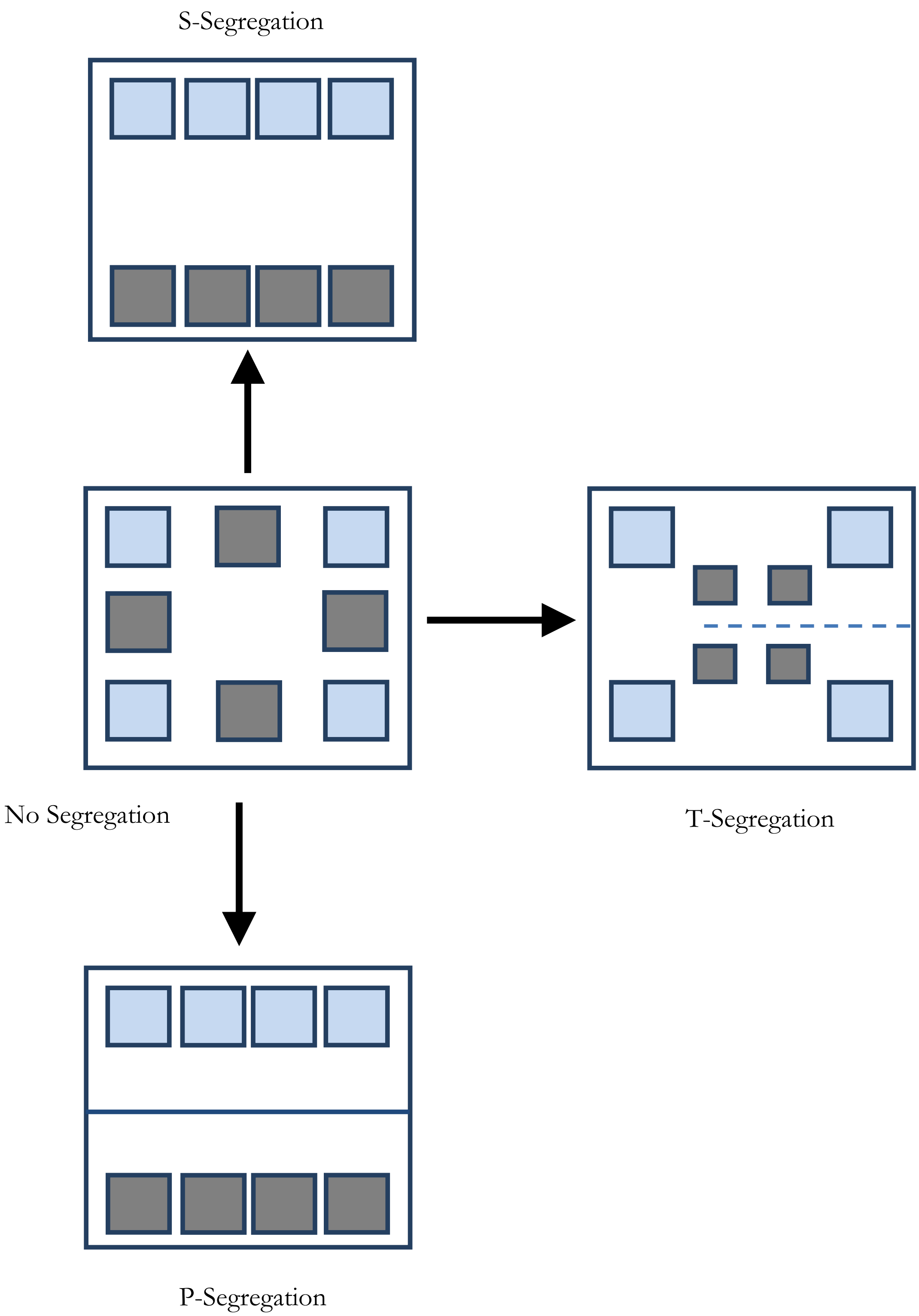


Figure 2. 1880 Census Population Map for Enumeration District 10 in Washington, D.C.

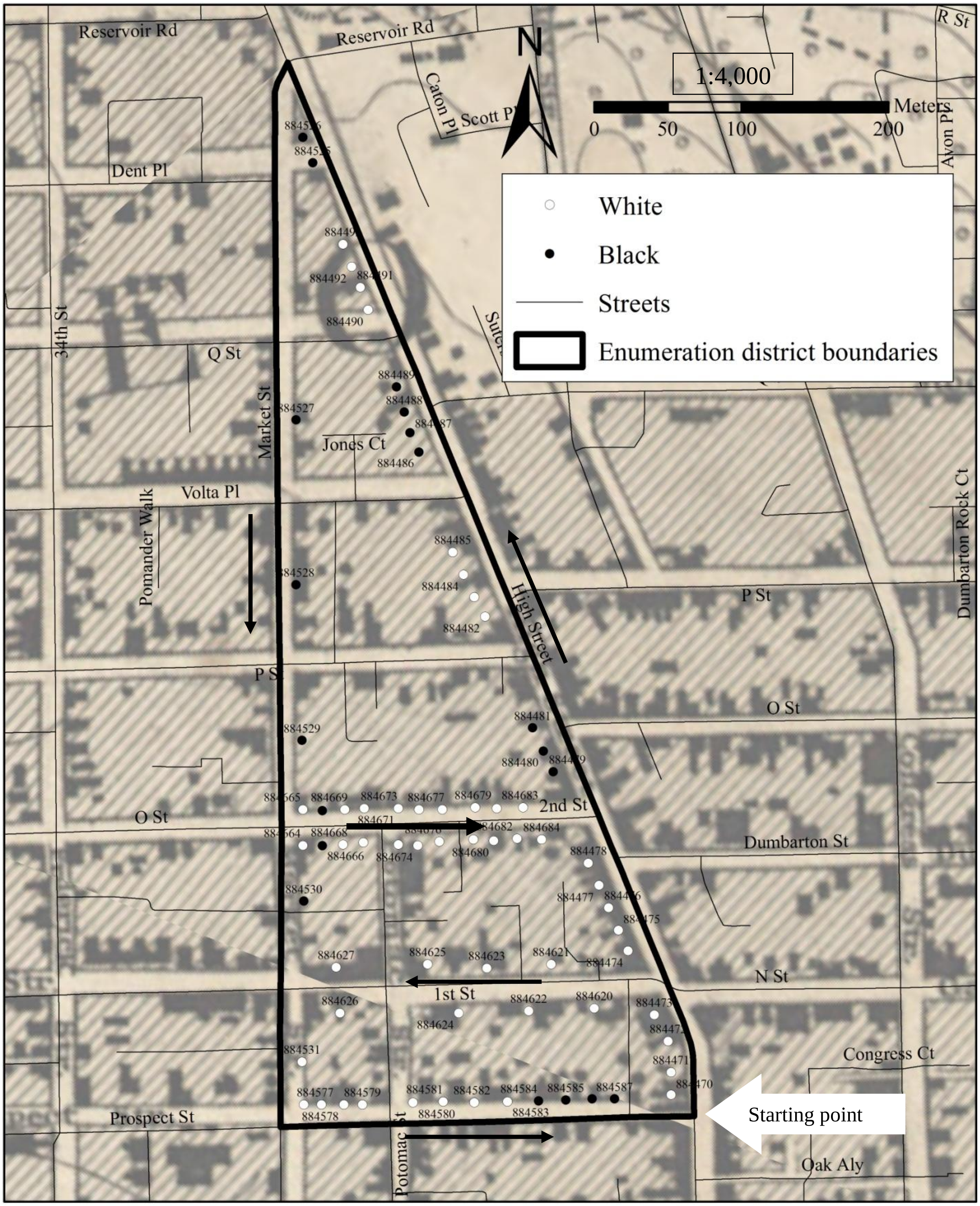


Figure 3. Enumeration Districts 51 and 52 (small rank-order difference between SIS and H)

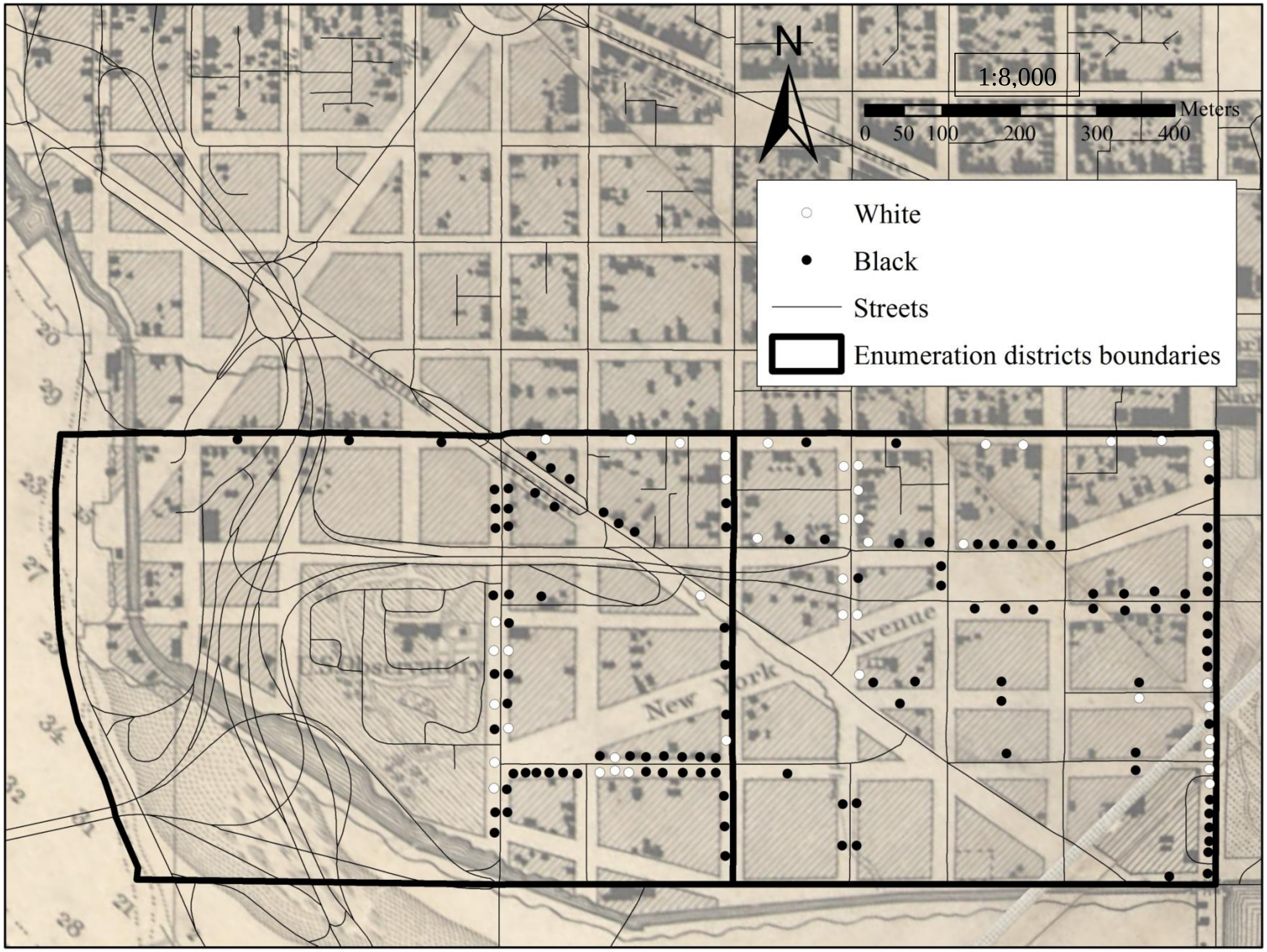


Figure 4. Enumeration Districts 19 and 20 (large rank-order difference between the SIS and H)

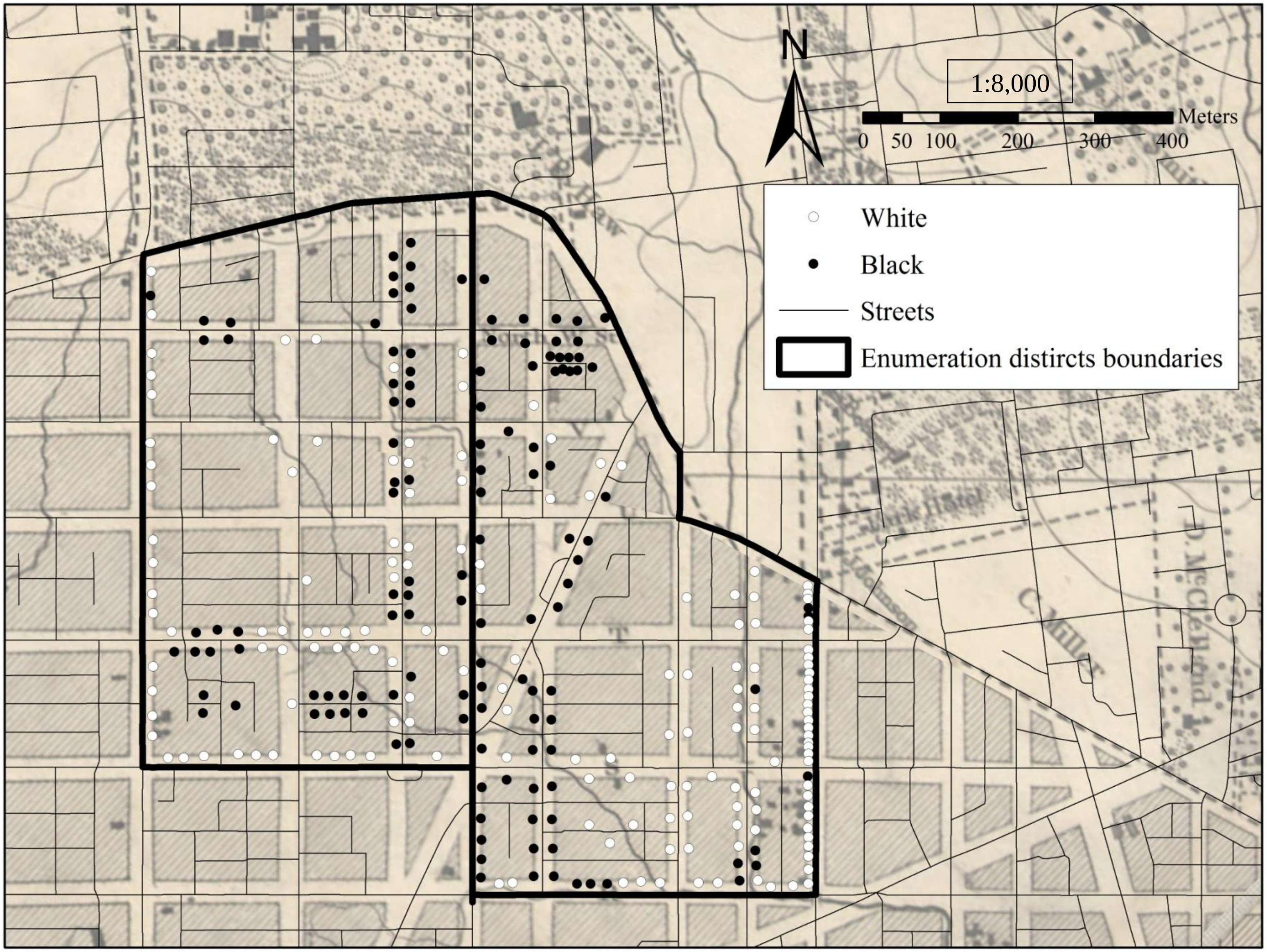
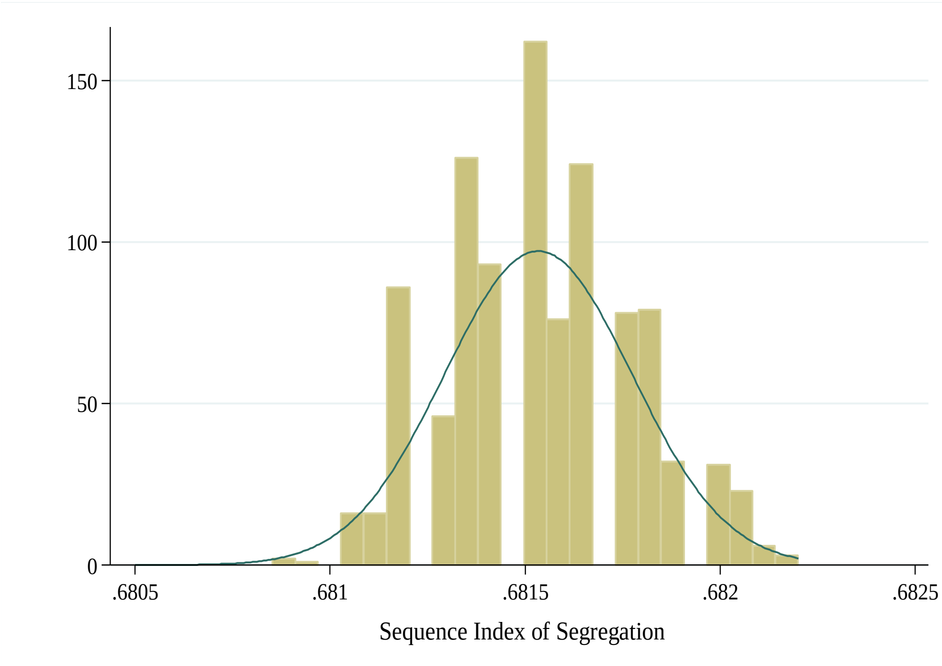
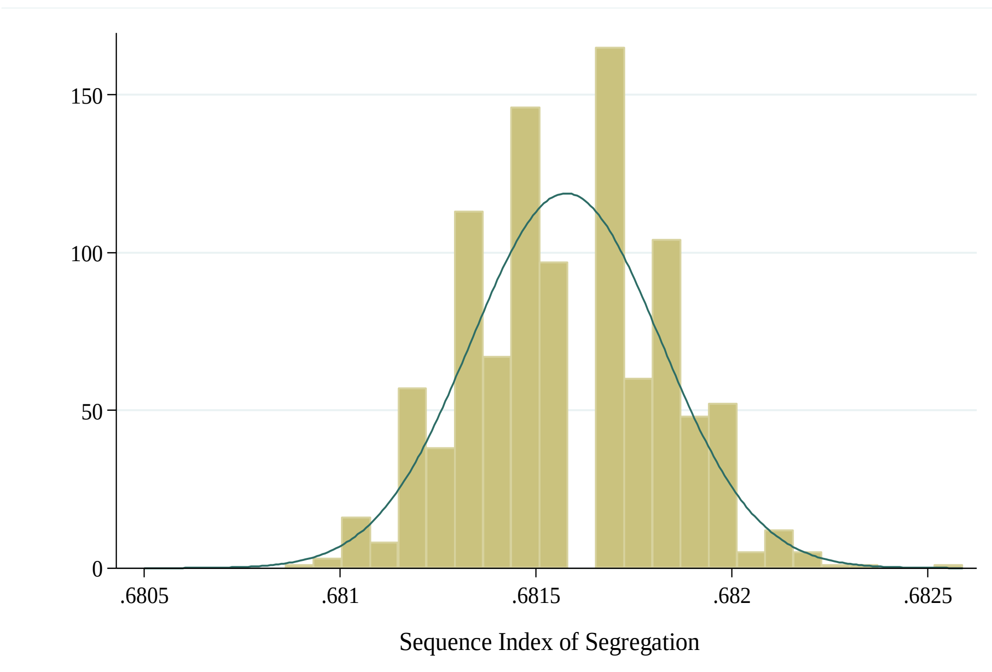


Figure 5. Frequency Histogram of SIS Values (with varying district order)



a. Enumeration Districts Ordered Randomly



b. Enumeration Districts Ordered Based on Spatial Contiguity